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THE WORLD'S GREATEST ADVENTURE—KANGCHENJUNGA, 28,156 FEET HIGH, THE SECOND HIGHEST MOUNTAIN IN THE WORLD (SEE PAGE 19)

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MR. MAXIM'S PAPER OF 1889

EINSTEIN'S Special Theory of Relativity, historically the parent if not logically the prerequisite of his General Theory, rests on a double foundation. On the one hand we have the realization, more or less clearly present for centuries though in part lost sight of by nineteenth century science, that uniform motion must of necessity be relative exclusively. On the other hand we have Einstein's startling assumption with regard to the constancy of the velocity of light, not relative to some universal medium but relative to all observers however conditioned.

That in the second-named pillar of his theory Einstein has presented something entirely foreign to previous human thought is plain enough. It would have been preposterous for anyone to suggest such an assumption prior to the development, out of the Michelson-Morley experiment and the Maxwell theory, of a group of experimental facts and theoretical considerations at variance with any other assumption which it has as yet occurred to human ingenuity to make. The date, 1905, when Einstein put forward his first paper on relativity probably marks the earliest moment when this extraordinary suggestion could have been received with sympathy by physicists or even by mathematicians.

If Einstein's second assumption is new and revolutionary, his first is well understood to follow more or less in the footsteps of classical science. From the time of the earliest philosophers men have realized with some degree of certainty that we can define motion only by means of something "assumed to be fixed"; and, with less certainty, have appreciated that the motion so defined is of significance only with respect to this chosen reference system. Now and then there has been someone who has ventured a little further than this in the direction of denying the significance of absolute motion. But such voices have been few and far between, and with the advent of the other hypothesis they became fewer and farther between; for it hardly seems possible to retain the ether and deny it the characteristics of a universal reference frame for absolute motion.

We reprint in this issue, from the SCIENTIFIC AMERICAN SUPPLEMENT of May 11, 1889, a paper by Hudson Maxim which, on the confession of its title, was devoted to the effort to prove that the ultimate particle of matter has real existence. The title did the text an injustice; it has a scientific content wider than the headline would suggest. In particular, we reprint it at this time chiefly because it contains what we believe to be the earliest unreserved statement of the universal relativity of uniform motion, with no loop-hole left for the man who would like to believe that after all there is, somewhere, something which if only he could find it he could use as a reference-frame for absolute motion. As explained in more detail on the editorial page of the SCIENTIFIC AMERICAN for July 2nd, we believe that, without detracting in any way from the credit due Einstein, Mr. Maxim may be conceded to have anticipated this phase of his philosophy *in toto*.

SHOOTING THE EARTH

FOR a number of years past a group of men in Christiania, Norway, have been trying to shoot the earth. They did not care what part of this planet they shot so long as they scored a hit. Yet strange as it may seem, they spent thousands of hours at this target practice without making a single score.

It would seem almost impossible to miss a bull's eye eight thousand miles in diameter, but large as it is, it proved to these marksmen a most difficult and illusive target. We may understand some of their difficulties when we learn that they located the gun from which they did the shooting, at a distance of ninety-three million miles from the earth, and for bullets employed projectiles so infinitely small that seventy-five million of them could be laid out in a single straight row within the space of an inch.

Instead of employing a muzzle velocity of three thousand feet per second which is high for a rifle bullet, the minute projectiles they used sped out the gun with a velocity many thousand times greater and this velocity was maintained by the projectiles throughout their course.

To be sure this was a mathematical target practice, or a sort of astronomical ballistics. It is just the sort of calculation that is performed in a plotting room to determine at what point of the heavens a gun must be directed in order to have its shell strike a target beyond the field of vision.

Some years ago the late Prof. K. Birkeland projected the theory that auroral lights are caused by a bombardment of cathode rays from the sun. These rays are formed by minute corpuscles which being electrically charged are diverted from their course by the magnetism of the earth and hence are confined within zones about the north and south poles. He demonstrated his theory by laboratory experiments. Then Prof. Carl Störmer of the University of Christiania undertook to plot the course of these minute projectiles. With the aid of a number of students, after a series of most laborious mathematical calculations, he succeeded in plotting the paths of a number of corpuscles but the particles would either glance off from the earth, or would describe loops around it without ever striking it. Then Professor Störmer reversed the process and undertook to work backward from particles which had reached the earth and determine their trajectories. In this he was finally successful.

Happily Professor Störmer knows how to write clearly and interestingly for the non-mathematical public and at our request he has prepared an article, fully illustrated with remarkable photographs of the northern lights and with models showing the paths of the cathode rays, which is published elsewhere in this number.

The Nature of Matter*

Principle of Force and Demonstration of the Existence of the Atom

By Hudson Maxim

Reprinted from the *Scientific American Supplement* of May 11, 1889

COEVIDENT with consciousness of our existence are certain truths.

Truth is the exact accordance with that which is, has been, or shall be.

Self-evident truth is that accordance with being which is too simple to require demonstration.

Complex truth is that accordance with being whose evidence requires demonstration.

A complex truth established upon self-evident truths is a concomitant certainty with the primary truths themselves.

There is no difference in truth. Self-evident truth is what, with all conditions necessary to its determination as absolute, is at once within consciousness of certainty. What truth is self-evident to one mind may not be so to every other. The greater the mind, the greater the truths that become self-evident. Some truths that are self-evident to the mind of a Newton, a Darwin, a Spencer, may be far beyond the comprehension of ordinary mortals. An axiom is any self-evident truth.

SELF-EVIDENT TRUTHS

Axiom 1.—A thing cannot, at the same time, be and not be.

Axiom 2.—That which exists as a composite whole, its parts, as units of the whole, also exist.

Axiom 3.—The whole is greater than any of its parts.

Axiom 4.—Every whole is equal to all its parts taken together.

Axiom 5.—If any part be taken from a whole, there remains such a part of the whole as has not been taken.

Axiom 6.—Division of a body is not annihilation of the body.

Axiom 7.—Nature extends without limit in all directions and contains all bodies, all space, all causes, and all effects.

Axiom 8.—No two solid bodies can occupy the same space at the same time.

Axiom 9.—An absolute solid completely fills the space occupied by its dimensions of extension.

Axiom 10.—No absolute solid can occupy more space than is equal to its dimensions of extension.

Axiom 11.—No absolute solid can occupy less space than is equal to its dimensions of extension.

Axiom 12.—An absolute solid cannot pass through the same space at the same time that it is occupied by another absolute solid. (Axiom 8.)

Axiom 13.—If an absolute solid be taken from a given space, there remains an absolute void of dimensions of extension equal to those of the solid body taken.

Axiom 14.—Motion is alteration of position or changing of place.

Axiom 15.—Force is any action between bodies which changes, or tends to change, their relative condition as to rest or motion.

Axiom 16.—There exists a certain something which we call matter.

Axiom 17.—There exists an attractive force between different portions of matter which we call gravitation.

ARGUMENT

Let us take the word "nature," as best suited to our use, and consider the term as embracing in its meaning all space, all matter, all causes, and all effects.

It is self-evident that nature must be either all an absolute void, or an absolute solid, or consist of both, perfect solids and void spaces.

Nature cannot be all an absolute solid, for in that case all motion were impossible. (Axiom 12.)

Nature, therefore, must be either all an absolute void, or consist of perfectly solid portions of matter and void spaces where matter exists not. (Axioms 9, 10 and 11.) One of these two alternatives must be true. (Axiom 1.)

Nature cannot be all an absolute void, for in that case all force and all motion were impossible; for if nothing existed, there would not be anything to move, or anything for force to act upon or between. And motion and force are as stated in Axioms 14 and 15.

Hence the only alternative left is that nature embraces spaceless solid units of substance and absolute void where substance exists not. For to demonstrate existence impossible except as claimed, of what is known to exist, proves the truth of the claim.

But let us argue this point a little further.

Let us take at the ordinary temperature of the air, what is termed a solid iron ball or sphere.

Now, it is self-evident that the sphere in question must be either all an absolute solid, or all an absolute void, or consists of both absolute solids and void spaces.

If we heat the sphere, we find that it expands, increasing its dimensions of extension in all directions; and on cooling again, we notice that it contracts to its former dimensions as it reaches its former temperature.

During these alterations in size we find that the weight or gravitative force of the sphere toward the earth remains unchanged. Hence the quantity of matter contained in the sphere is neither increased nor diminished. And, as an absolute solid could neither expand nor contract in size (Axioms 8, 9, 10), we know that the sphere in question cannot be all an absolute solid, but must contain void spaces.

We know that it cannot consist wholly of spaces, or else it would be nothing but void. (Axioms 1, 8, 9, 10.) Hence the sphere must consist of both void spaces and spaceless solids possessing certain dimensions of extension in length, breadth and thickness.

And the dimensions of extension of all the solid atoms plus the dimensions of extension of all the vacant spaces of any body are exactly equal to the dimensions of extension of the whole body; for the whole must be equal to all its parts (Axiom 4), and must require all its parts to complete the whole.

But it is argued that as we know nothing of matter except through force, force may be either a property of matter or matter be but a property of force.

It is self-evident that force is what it is claimed as being in Axiom 15, and hence cannot have being except in being what it is (Axiom 1)—the action or power of something exerted upon something, or action between two or more things or objects.

Therefore, as force can exist only as a condition of more than one thing, if we take away from the ultimate whole wherein force is considered, all of the parts except one, between which the exertion of force exists, we have one part left (Axiom 5), but no more. What, then, must that part be which is left?

The certainty that it exists (Axioms 1 and 5), the certainty that it cannot be force, the certainty that it can be nothing else, demonstrates that it must be absolutely solid substance. (Axiom 4.)

Let us now conceive of but one of these ultimate solid atoms as existing entirely alone in all space, assuming that it alone be all the matter or substance in existence.

*See editorial on preceding page.

It could have no motion in any direction, for space of itself without limit is without direction, and no place in space could have position relative to the rest of space—hence position and place as relative to but space are impossible, therefore, a single ultimate atom existing alone in space could have no motion, as it could not alter its position, having no position or place to change.

Hence, direction, distance, position or place are terms which relate to conditions of existence of more than one unit of existence or atom, excepting as relates to points within its own dimensions, and being an absolute solid, no point within itself can change its position relative to other points. Hence all motion were impossible with an ultimate atom existing alone in space.

The ultimate solid could have no axillary motion, as no point within its dimensions could alter its position relative either to other points in the solid unit or to space.

The conception of a centrifugal force from an axillary motion, as tending to separate the ultimate atom into parts, is untenable, for the ultimate atom being a perfect solid must also be absolutely unbreakable, as well as absolutely incompressible, as will be more fully shown further on.

A single ultimate solid existing alone in space could possess no attracting or repelling force or power—as there would be nothing for it to attract or repel.

Therefore position, place, force, and motion are conditions of existence of more than one ultimate atomic solid.

If we now conceive of another like ultimate solid atom as existing along with the first, an attracting force, or a repelling force, or both, according to distance, and the concomitant conditions of position and motion are possible.

But it is self-evident that as no change can take place in the ultimate solid, the only effect force is capable of producing, and the only force that is possible to exist, is the changing, or tending to change, the condition of the atoms as to rest or motion relative to one another.

Now, if a single ultimate solid existing alone in all space can possess no force, and in itself is incapable of undergoing any change; and if the addition of another ultimate solid along with it adds force, and the conditions of position and motion being the only conditions possible, if we add an infinite number of atoms we have an infinite force, and by infinite combinations of atoms we have infinite manifestations of force, but necessarily of the same force, as the only possible manifestation of force is in the change of the relative condition of atoms as to rest or motion, as all changes must occur outside of the atom, for the atom is of itself unchangeable.

ANSWERS TO ARGUMENTS AGAINST THE EXISTENCE OF THE ATOM

The principal arguments against the existence of the atom which I have seen are those advanced by Herbert Spencer and by Boscovich. Spencer, in his "First Principles," page 51, says: "Were matter thus absolutely solid, it would be what it is not, absolutely incompressible, since compressibility, implying the nearer approach of constituent parts, is not thinkable, unless there is unoccupied space between the parts. Nor is this all. It is an established mechanical truth, that if a body, moving at a given velocity, strikes an equal body at rest in such wise that the two move on together, their joint velocity will be but half that of the striking body. Now it is a law of which the negation is inconceivable, that in passing from any one degree of magnitude to any other, all intermediate degrees must be passed through. Or in the case before us, a body moving at velocity 4 cannot, by collision be reduced to velocity 2 without passing through all velocities between 4 and 2. But were matter truly solid—were its units absolutely incompressible and in absolute contact—this 'law of continuity,' as it is called, would be broken in every case of collision. For when, of two such units, one moving at velocity 4 strikes another at rest, the striking unit must have its velocity 4 instantaneously reduced to velocity 2, must pass from velocity 4 to velocity 2 without any lapse of time, and without passing through intermediate velocities; must be moving with velocities 4 and 2 at the same instant, which is impossible."

Spencer here bases his argument on what he supposes to be an immutable law of nature; that a moving body cannot pass from velocity 4 to velocity 2—that is, from a given velocity to a velocity half as great at the same instant.

Let us conceive of a body being projected perpendicularly from the earth in such wise that it shall ascend and descend in the same line. It certainly must stop at the point whence it begins to descend, and as it must move at some velocity until it stops, it must pass instantly from velocity something to velocity nothing, which is as great as from velocity 4 to velocity 2.

For, suppose the force of gravitation were instantly removed at the same instant that the ball was moving at its last degree of velocity, the ball would continue to ascend, and however slowly it moved, would travel a given distance, say twelve feet, in sufficient time, and if it moved with only half that velocity, it would travel six feet in the same time.

Now, a velocity of twelve feet in a given time is to a velocity of six feet in the same time as velocity 4 is to velocity 2. Therefore, to stop at all, a moving body must pass instantly from some velocity to some other equally less as from velocity 4 to velocity 2.

Again, suppose we were to project a body perpendicularly from the earth at the rate of a thousand feet per second.

From the moment it leaves the earth, the attraction of gravitation acting upon it, continually retards its motion until it stops; and each point throughout the line of its ascent must mark a degree in the reduction of its velocity, and hence it must sacrifice one degree of its velocity in attaining the height of each succeeding point throughout the entire line of its ascent until it comes to a stop.

Now, let us project a like body from the earth in the same manner and with equal force, but let us conceive of a gravitative force twice as great, which, acting upon the ascending body with double the retarding force exerted upon the first body, would bring it to rest at half the height attained by the first body.

Hence it must instantly lose twice as much velocity at each point of its ascent as did the first body. It must instantly lose twice as much velocity in the same time as did the other body when acted upon by the lesser gravitative force.

Therefore Spencer's argument amounts to nothing; for what he claims as impossible is so simple a truth that it may well be considered an axiom, as follows:

A moving body encountering a resisting force instantly loses such velocity as is exactly equal to the resisting force it at each or any instant encounters.

The theory of Boscovich is substantially that the constituents of matter are centers of force or ultimate units of force, points without dimensions which attract and repel one another in such wise as to be kept at specific distances apart. That is, that matter is but an attribute of force, instead of force being an attribute of matter.

We have already demonstrated this theory impossible. However, let us for argument's sake conceive of one of these force centers of Boscovich as existing entirely alone in all space, as we have already considered the ultimate solid.

Now it is self-evident that force as stated in Axiom 15, "is any action between bodies which changes or tends to change their relative condition as to rest or motion," and as a thing cannot be, and not be, at the same time, it is certain that force cannot be, where it can have no effect or tendency to induce change.

Now a single force center or unit of force existing alone in all space must still exist as force if it exist at all, and existing alone, there would be nothing but itself as an object of its action or tendency; and as force can exist only as action or tendency to induce change, the claim that a unit of force could exist alone is untenable, for it could so exist

only in action or tendency, and consequently negative the possibility of a unit of force existing alone, and the possibility of any truth in the force center theory.

But it is asked in argument by disciples of Boscovich if matter be composed of solid units of substance, what is it that holds together the parts of that body if it be not a cohesive force? And if one of these solid bodies were sundered by a sufficient force, what, but a cohesive force, would hold together a fragment into which it might thus be broken? And so on until we come to centers of force without any dimension.

Division of a body is not annihilation of the body, and no matter how far we carry division in thought, or how far conceive of possibility of carrying it, still a whole must be equal to all its parts taken together; and however infinitely small the parts into which a body may be divided, still the sum of the dimensions of extension of all the parts taken together must equal the dimensions of extension of the original whole; and thus any part, however small, must have dimensions of some extent.

The fact is, our ideas of breaking and separating of bodies are but our impressions from associated ideas. Could we possess infinite powers of vision, we would see that what we deem breaking of substance is in all instances but a moving apart of different substances, the same as the moving of a stone from the earth by lifting the stone, and that absolute fracture or breaking into fragments of absolutely solid substance is not in the course of nature or range of possibility.

We have come to reason inductively that all things must be breakable by the application of a sufficient force, and that some force must be sufficient.

Let us see about this. Suppose we conceive of an absolute solid, a perfect sphere in form and of sufficient size to be tangible to our senses.

Let us apply to every part of its surface a force "sufficient" to compress it. It is evidently now compressible. (Axiom 11.)

In the consideration of a force as tending to compress an absolute solid, all forces are equal to one another and hence all equal 0—thus the term sufficient is inapplicable, the same as no time could be sufficient to end eternity, or distance sufficient to extend to the end of space. Nothing could be sufficient to render an impossibility possible.

Let us reverse this force and let there be a force acting upon every point on its surface sufficient to pull an absolute solid asunder; is it not evident that it would be equally as unbreakable as incompressible?

It is self-evident that no force whatever, equally applied to every point of the surface of an absolute solid sphere could compress it. Suppose we reverse that force, and consider force in any degree of amount as drawing equally in all directions outward from every point of its surface, how and where could fracture occur? Being a perfect solid, its cohesive force or tensile strength, if considered in the light of a force or strength, must be absolutely equal throughout every point of its entire dimensions, hence such force could tend to produce no other effect than absolutely equal expansion throughout its entire dimensions. That is, it must expand so that no one point or portion shall be more solid or rarefied than any other—that is, it must expand and still retain itself a perfect solid, which is impossible. (Axiom 10.)

SUMMARY OF DEDUCED TRUTH

First.—All matter exists in ultimate atomic units of absolutely solid unchangeable substance.

Second.—With but one ultimate atomic solid existing alone in all space, all force, motion, or change of condition would be impossible.

Third.—With but two or three ultimate atomic solids existing alone in all space, attraction, or repulsion, or both, according to distance from one another, would be the only possible forces that could exist. And the only possible change that could be wrought by these forces in the condition of these atoms would be a change of their conditions as to rest or motion by changing their positions relative to one another. Adding any number of atoms adds no new force, neither makes any new force the more possible, but increases the possibilities of the same force directly as the squares of their numbers, and inversely as the squares of their distances from one another.

Fourth.—The sum of all the forces of all nature at the present moment is exactly that of the sum of gravitative force and of the momentum acquired by its ultimate atomic solid units in their nearer approach to one another, occasioning the passage of matter from a rarer to a denser form.

Fifth.—All events of all history and all phenomena, and all evolutions of organic and inorganic, animate and inanimate nature during all time, have been exactly those which have resulted from the sum of the combined forces of all the atoms in existence acting upon one another.

Sixth.—Every atom in existence follows a course mathematically exact—that which is determined for it by the combined forces exerted upon it of all the other atoms in existence. And every atom in existence follows a course as mathematically exact under the combined influences exerted upon it as do the heavenly bodies.

Seventh.—Could all the atoms in existence be instantly placed in exactly the same position relative to one another that they occupied just one thousand years ago, possessing the same acquired momentum they then possessed, every heavenly body would again pass through exactly the same change of position relative to one another that they have passed through during the last thousand years, and all would again at the end of one thousand years be in exactly the same positions that they now occupy. And the same with every earthly event, everything would reoccur in the history of men exactly the same, and all things reoccur exactly the same and in the same order as they have occurred during the last thousand years, and we should again all be here, the history of all our lives be the same, and we should all again be educated by the same influences which determine us to work our own destiny without changing the nature of a single atom or swerving one from its destined course.

There can be no effect without a cause, and there can be no cause which is not itself an effect of a preceding cause. Every effect is a cause for effects exactly equal to itself.

There can be no more effects in nature than are exactly equal to producing causes. And there can be no more causes for effects than is exactly equal to the effect to which nature owes those causes, which are the causes of those causes.

The ultimate atom is the unit of measure of power in all effects.

ELECTRIC DOUBLET THEORY OF GRAVITATION AND RADIATION

IT is suggested that gravitation may be an effect arising from fluctuations of the electric charges associated with the electrons and positive nuclei of atoms. It is assumed (1) that the ether contains an enormous number of electric doublets moving in all directions with the speed of light; (2) that each charged particle is continually both absorbing and emitting doublets at a rate proportional to its mass; and (3) that during the absorption and emission of each doublet the charge on the particle fluctuates. If these fluctuations exist, it is shown that the mean value of the force exerted by one charged particle on another includes, in addition to the ordinary electrostatic force, an attraction proportional to the product of the masses.

If we suppose that the doublets emitted by a particle possess available energy only when the energy of the particle changes, and that the effect of changing the energy is to produce periodic gaps in the emission of doublets with a frequency proportional to the amount of energy lost, we have a theory of radiation which is said to be compatible with the theories of Bohr, Planck and Einstein.—H. Bateman in *Phys. Rev.*, January, 1921. Abstracted through *Science Abstracts.*

Einstein's Theory of the Universe

The Hypersphere—a Universe Unbounded but of Finite Volume

By L. P. Eisenhart
Professor of Mathematics, Princeton University

WHEN Einstein applied his theory of general relativity to the paths of light, he came to the conclusion that the path of a ray of light passing near the sun would be bent toward it. When experiments, made in 1919, verified this prediction not only in fact but in amount, scientists began to believe in the theory of relativity. But when Einstein announced that, in accordance with the principles of relativity, the universe is finite and yet unbounded, people in general became interested and wanted to know what this meant.

The classical mechanics of Galileo and Newton rests upon the assumption that space extends indefinitely in all directions and that its properties are set forth in the plane and solid geometry of Euclid which we studied in school. It is also assumed that time and space are independent entities. We have been in the habit of thinking that matter is distributed throughout this space in all directions. When new stars at greater and greater distances reveal themselves as our telescopes become more powerful, we naturally become more convinced that our space is infinite in all directions and that there is matter everywhere in it. But is this conclusion in accord with the application of the Newtonian theory of gravitation to the universe as a whole?

When we speak of the mean density of the matter in a body we mean the quantity of matter which would be contained in a unit volume of it, if the matter were uniformly distributed throughout the body. Consequently the quantity of matter in a body is equal to the product of its mean density and volume. If the quantity of matter in a body is unchanged as its volume increases, the mean density necessarily decreases. An example of such a state of affairs is afforded by a balloon containing gas; when the gas expands enlarging the balloon, the mean density of the gas becomes smaller. Likewise the mean density of matter in the universe would be the quantity of matter in a unit volume of the universe, if all the matter were uniformly distributed. It will be necessary to consider the two possibilities, when the mean density for the universe is different from zero, and when it is zero. The latter would be the case if all the matter in the universe were finite in amount and were contained in a finite portion of it, the remainder of space being void of matter. The mean density of the matter in this finite portion would be different from zero for this finite volume, but the mean density of matter in the whole universe extending indefinitely in all directions would be equal to zero. For the product of a finite mean density and an infinite volume would necessarily give an infinite quantity of matter, which is contrary to the above assumption.

Suppose that we consider the matter in the universe distributed throughout it and the mean density to be different from zero. Let us consider now a very large spherical portion of the universe, and the behavior of a body at a point of its surface due to the attraction of the matter within, whose mean density is approximately equal to the mean density of the universe. In accordance with Newton's law of gravitation and a theorem due to Gauss, this body would be attracted by a force proportional to the product of the radius of the sphere and the mean density of matter. As the sphere became larger the force acting upon the body would be increased without limit and consequently also the velocity of the body. Astronomers have no knowledge of velocities of the magnitude which this would necessitate.

The above argument would not apply if the mean density of matter in the universe were zero. We have seen that such would be the case if all the matter in the universe were finite and were contained in a finite portion of infinite space, the remainder of space being empty. The objection to this hypothesis is that energy in the form of light would be radiated into the portion of space void of matter and would be lost, and consequently there would be a continual reduction of the energy in the universe. Again, the astronomer Seeliger, who was the first to call attention to the difficulties which arise when the Newtonian law of gravitation is applied to the universe as a whole, proposed the possibility of matter of negative density so that the mean density could be zero—an assumption which is not satisfactory.

Is there any reason for expecting the general theory of relativity to yield an acceptable solution of this problem? One of the fundamental principles of this theory is that the character of space is determined by the matter in it, and in fact the very existence of space is conditional by matter. There is no *a priori* assumption as to the character of space, that is as to the geometry of space. Its geometry is a practical geometry; it is determined by experience. All of us have been schooled to such an extent in euclidean geometry that most of us have come to think of only one kind of geometry. However, the geometers have been developing other kinds of geometry and in order to proceed further with the present subject we must consider certain of these ideas.

The plane geometry of Euclid and plane trigonometry deal with the properties of a plane involving measurement, that is, its metrical properties. Accordingly we say that a plane is a *two dimensional euclidean space*, meaning by two dimensional that any point in the plane is determined by its distances from two perpendicular lines in the plane, just as a point on a sheet of paper is determinned by its distances from two adjacent edges. This idea has been generalized to the whole of our space, which we call euclidean space of three dimensions, meaning thereby that any point of the space is determined by its distances from three mutually perpendicular planes, just as a point in a room is determined by its distances from two adjacent walls and the floor. These three distances are called the *coördinates* of the point. Any three quantities which determine the points of euclidean space are called coördinates. There are innumerable systems of coördinates which can be used.

Any cylinder in euclidean three space can be rolled out upon a plane, or is *applicable* to the plane. The lines along which shortest distances on the cylinder are measured, called its geodesics, become straight lines when the cylinder is applied to a plane; and the angle between two such lines is unaltered in the process. Hence the geometry on the surface of the cylinder is the same as for the plane. Accordingly we call the surface of a cylinder, or any other surface applicable to a plane, a *euclidean two dimensional space.*

A sphere is not applicable to a plane, and consequently the metrical properties of the surface of a sphere are different from those of a plane; we realize this when we recall the theorems of spherical geometry and the formulas of spherical trigonometry. Therefore we say that the surface of a sphere is a *non-euclidean two dimensional space;* that it is two dimensional is seen when we recall that any point on a sphere is determined by its latitude and longitude which are the coördinates of the point. In general any surface which is not applicable to a plane is a *two dimensional non-euclidean space;* its points are determined by two coördinates.

The theorems of spherical geometry are ordinarily derived by making use of the geometry of the euclidean three dimensional space in which we think of the sphere as lying. But the theorems which apply to the surface of the sphere itself can be obtained from a set of axioms or postulates, without refer-

ence to three dimensional euclidean geometry. We say that these metrical properties are intrinsic to the surface as such. It may be objected that these axioms presuppose knowledge gained from the consideration of the sphere as lying in euclidean three dimensional space. Consider, however, the problem of measurement upon the surface of the earth. We find that for sufficiently small portions of the earth the metrical properties of euclidean geometry can be used. But when measurements over a considerable portion of the earth are made this is no longer the case. On the earth lines of shortest distance, or geodesics, are great circles. The surveyor would discover, if he were not acquainted with solid geometry, that the sum of the angles of a large triangle is greater than two right angles, and that its excess over two right angles is proportional to the area of the triangle. Thus by measurement the metrical properties of a sphere can be found out. Any point P of the sphere is determined by its distance from a point O, and the angle between the great circle through O and P and some other great circle through O. In terms of these coordinates a formula for distance between any two points on the sphere can be established. From this formula, called the metric, other geometrical properties of the sphere can be deduced.

There is another essential difference between a spherical surface and a plane. All points of the former lie in a finite area and this area has no boundary in the surface itself, whereas all the points of a plane do not lie in a finite area, nor is there a finite area of a plane without a boundary in the plane.

The geometer has generalized the idea of euclidean space to euclidean spaces of any number of dimensions just as the three dimensional space is a generalization of the plane. Also he has generalized the non-euclidean spaces of two dimensions into non-euclidean spaces of any number of dimensions. Thus the geometer conceives of a three dimensional non-euclidean space lying in a four dimensional euclidean space which is a generalization of a sphere lying in our space as we have thought of it; he calls it a hypersphere, speaks of its radius, and considers it to be unbounded, just as we observe the surface of a sphere to be without bounds. The geometer can write down the equations for such a space and also the expression for distance, that is the metric of the space, from which the metrical properties of the space can be derived. However, in considering these metrical properties of the hypersphere it is not necessary for him to think of it as lying in euclidean four-space; that is, he can develop the geometry of a hypersphere intrinsically.

In the consideration of physical phenomena both time and space enter. In the classical mechanics these two entities are considered to be independent of one another, and until recently it was generally conceded that there is an absolute space and an absolute time whose intervals could be measured by different observers regardless of the relative conditions of these observers. However, in accordance with the theory of special relativity, the measurements of space-intervals and time-intervals involved in certain physical phenomena are not absolute, but depend upon the position and velocity of the observer. Moreover, what one observer interprets as a time-interval or space-interval another observer may interpret as involving both space and time. Hence it becomes necessary to treat space and time together, so that in considering physical phenomena we speak of a space-time world which is four dimensional; it depends upon four coördinates. Einstein formulated the principle that physical laws must be expressed in a form not depending upon a particular observer; or as the mathematician puts it, physical laws must be expressed in a form invariant with respect to the system of coördinates used.

The general theory of relativity embraces all kinds of physical phenomena and makes use of the idea of a space-time world of four dimensions. The equations are expressed in a form invariant with respect to the system of coordinates used. The theory distinguishes between a gravitational field and matter, the latter embracing everything except gravitation; that is, matter includes electro-magnetism. Ordinarily the coördinates of space are not distinguishable from the coördinate of time. However, it is possible to distinguish between these elements in the case of planetary motion about the sun. In this case the equations of motion of a planet differ little from those obtained by the Newtonian method, but this difference accounts for the discrepancy in the motion of the perihelion of Mercury discovered by Leverrier.

When one considers the space in the neighborhood of the sun in which the planets move, it is seen from the metric of the space, obtained from the Einstein equations, that its metrical properties are those of a non-euclidean space of three dimensions. Einstein holds that the metrical character of the space is determined by the matter in the sun; that the space differs from euclidean space because of this matter. Accordingly he predicted that light passing through this space would not move in a straight line, but would be bent toward the sun.

As stated above, the equations of general relativity are applicable to any physical phenomenon. It is natural, therefore, to ask what information these equations give as to the metrical character of the universe as a whole. Although Einstein recognized the fact that matter is not uniformly distributed throughout space, he felt that by assuming a uniform distribution of mean density different from zero, he could get an approximate idea of the metrical character of space. On the assumption also that the motion of matter is very small as compared with the velocity of light, he was able to differentiate between the coördinates of space and the coördinate of time. When the equations of general relativity were made to conform to these conditions, it was possible to arrive at a unique conclusion as to the metrical character of physical space as a whole. The interpretation of the result by a geometer is as follows: The universe of physical phenomena is a hypersphere; its radius depends upon the mean density of matter in the universe and the space is of finite volume; the universe is not bounded just as the surface of a sphere does not have any boundary in the surface itself.

It may be all right for the mathematician to say that he can develop his imagination so as to speak of a hypersphere as a reality, but how about the physicist and the man who is concerned only with the realities of experience? Einstein lays emphasis upon practical geometry, the geometry of experience. He insists that we must not make an *a priori* assumption concerning the metrical character of space, but that we must be guided by the results of measurement. The purpose of any physical theory is to give a mathematical formulation which agrees with experiment, and from which predictions can be made concerning phenomena which have not yet been tested by experiment or which at present are beyond the range of experiment. Our present knowledge of the masses and special distribution of the fixed stars is not sufficient for us to determine with exactness the mean density of the universe, the knowledge of which is essential to the testing of the above results. We feel sure that the mean density is very small. On assumptions as to its magnitude, we can readily calculate the radius of the hypersphere. But as yet we must admit that these are assumptions. When definite knowledge of the magnitude of the mean density comes into our possession we can determine by physical measurement whether we must revise the conception of our space which has been drilled into the human mind for centuries. It was difficult to convince mankind that the universe is not geocentric. There is no reason to suppose that if experience demands it, the mind of the future will not develop the capacity to think of a finite and unbounded universe.*

*For the mathematical treatment of this subject see Einstein, Kosmologische Betrachtungen zur Allgemeinen Relativitätstheorie, Sitzungsberichte der Preussicher Akademie der Wissenschaften, Feb., 1917; the subject was treated by Einstein also in an address before the Prussian Academy, January 27, 1921, entitled Geometrie und Erfahrung, and in his Princeton Lectures, which will be translated into English and published by the Princeton University Press.

FIGS. 1-3. AURORAL CARONAE PHOTOGRAPHED FROM BYGDÖ, NEAR CHRISTIANIA

Fig. 1 was taken on March 22, 1920, at 7 h. 44m. P. M., Greenwich time; Fig. 2 was taken at 1h. 5m., and Fig. 3 which shows a corona of wonderful blue color was taken on the morning of March 23

The Aurora Borealis

A Mystery of Nature, Elucidated During the Course of the Last Few Decades

By Prof. Carl Störmer, of Christiana, Norway

On March 22nd, 1920, there appeared over the greater part of the earth a display of northern lights, the form and beauty of coloring of which were unique, and which aroused the keenest attention among all investigators. In the United States of America it was observed at one hundred places, scattered over the country from the eastern States right to the west of California. Simultaneously the southern lights appeared in the southern hemisphere, being observed, for instance, in Australia. This display of northern lights, which also appeared in great splendor in Europe, was observed by my assistants and myself from a number of stations in southern Norway. These stations were connected with each other by telephone, and provided with cameras so that many hundred successful photographs were taken in the course of the night. As they were taken simultaneously at several stations, the height and situation of the northern lights can be calculated with accuracy. It appeared that on that night the rays of the northern lights reached quite exceptional heights, between 500 and 600 km. above the earth.

Figs. 1, 2 and 3 show photographs of auroral coronæ taken with an exposure of a few seconds from my main station at Bygdö, near Christiania.

By request of the Editor of The Scientific American Monthly, I will give in the following a short survey of the investigations which I have undertaken in recent years, in order to explain the nature of the northern lights.

THE PROBLEM OF PHOTOGRAPHING THE NORTHERN LIGHTS. RESULTS OF THE PHOTOGRAPHIC CALCULATIONS OF HEIGHT

As all usual observations of the northern lights are more or less subjective and unreliable, it is of the greatest importance to obtain an objective method, and the only reliable one is in the present case photographic. For many years the problem of photographing the northern lights resisted all efforts. It was not until 1892 that Brendel succeeded in obtaining a fairly serviceable picture by an exposure of 7 seconds during a stay at Bossekop in the north of Norway. More pictures with short exposures were not published, until in 1909 I commenced systematic investigations in order to solve the problem. By the use of a small cinematograph lens with a

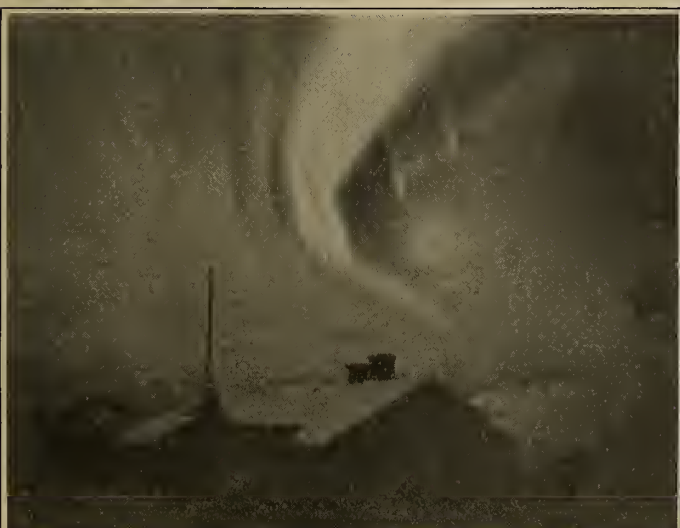


FIG. 4. NORTHERN LIGHTS TOWARD THE WEST, AT BOSSEKOP, FEBRUARY 28, 1913

FIG. 5. NORTHERN LIGHTS IN THE EAST, AT BOSSEKOP, MARCH 3, 1910

25 mm. aperture and a focal length of 50 mm. and Lumière *etiquette violette* plates, I succeeded in obtaining serviceable pictures with exposures of a few seconds, and in consequence I undertook two northern lights expeditions in 1910 and 1913 to Bossekop, in order to apply photography to the study and measurement of altitude of the northern lights. Bossekop, which is situated near Alten Fiord, 80 kilometers south of Hammerfest, is a classical spot for the investigation of the northern lights, and in the course of time has been visited by many scientists.

FIG. 6. THE CAMERA USED IN PHOTOGRAPHING NORTHERN LIGHTS

On these expeditions my assistant meteorologist, B. J. Birkeland, and I took many hundred successful photographs, of which a few will be reproduced here.

Fig. 4 shows a northern light display in the form of a multiple band, which extended from west to east above the zenith, with a beautiful blue-white color. The star Procyon will be seen in the center of the picture.

A beautiful yellow-green auroral band with bundles of rays will be seen in Fig. 5. These bands or draperies are very remarkable; they may have a length of many hundred kilometers.

Fig. 6 shows one of the cameras which were used on the expedition of 1913. To the left will be seen an arrangement whereby the image of an illuminated watch was photographed on the plate simultaneously with the northern lights. It was thereby possible to read the time direct on the plate and it was unnecessary to take time observations during the work.

This arrangement was particularly useful when the northern lights developed in great beauty. The pictures could then be taken quickly one after the other with registration of time for each picture.

We also successfully employed a cinematograph, and obtained series in which each picture was illuminated for about 4 seconds. Part of a series of this kind, taken in 1913, is seen in Fig. 7.

However, of considerably greater interest was the method, which I introduced for the first time on my expedition in 1910, for the photographic measurements of the altitude of the northern lights. The method is as follows:

From two stations at a distance (of about 30 km.) from each other, and connected by telephone, the northern lights are photographed after orders by telephone, both cameras being directed toward the same star. From the different positions of the northern lights on the plates, the altitude above the earth can be estimated, since the situation and the time are known.

As early as in 1910 there were obtained in this way a series of reliable calculations of altitude, and in 1913 the work was continued under considerably improved conditions. The result was no fewer than 2,400 determinations of altitude, which showed that the northern lights do not extend lower down in the atmosphere than about 87 km., and that the bulk of the northern lights and those with the greatest intensity of light occur between 95 and 120 km. Some forms, however, particularly the summits of the auroral rays, lay considerably higher, *i.e.*, more than 300 km.

We will here describe only one of these photographs.[1]

The photograph depicts a beautiful yellowish-green auroral drapery toward the west, and the planet Venus is seen in the middle of the picture, to the right slightly obscured by a cloud. On account of the small altitude of the cloud the latter is far beyond range of vision in the picture to the left, while the northern lights, the lower edge of which lay at a height of about 100 km., are only slightly displaced in relation to Venus. The lowest point of the pictures was situated at a distance of about 700 km. above a region half way between Norway and Greenland.

In recent years the same method has been employed in southern Norway. From my main station at Bygdö, near Christiania, I have had telephonic connection with a number of secondary stations, at distances varying from 26 to 250 km., and a large amount of material,[2] consisting of about three hundred simultaneous auroral photographs, was obtained during the lears 1916-1921. In addition, a number of characteristic single photographs were taken, a few of which I here reproduce.

On the night between the 7th and 8th of March, 1918, a beautiful display of northern lights was observed both in Europe and in America. It began with an auroral arc in the north as shown in the illustration, and later on at about 1 o'clock (Greenwich time) there came beautiful rays and a corona formation. See Figs. 10 and 11.

We will not enter into further details regarding the results of the photography of the northern lights, but will proceed to give as popular an explanation as is possible of the nature of the northern lights.

EXPLANATION OF THE NATURE OF THE NORTHERN LIGHTS.

As early as the year 1881 Goldstein formulated the idea that the sun sends out into space, streams of particles loaded

[1]A complete account of the expedition of 1913 will soon appear in print in the *Geofysiske publikationer* (Christiania).

[2]Of these only a few of the specially interesting results have been prepared and published.

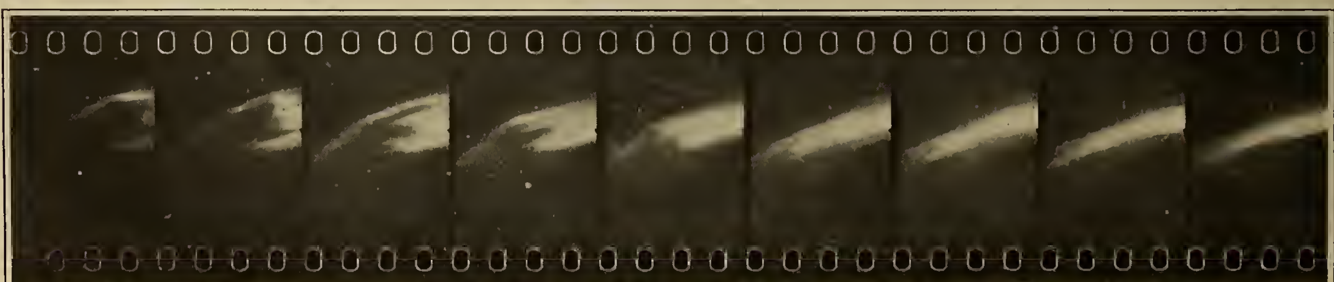


FIG. 7. STRIP OF NOTION PICTURE FILM OF THE AURORA BOREALIS

with electricity, which possibly cause electric and magnetic phenomena on the earth.[3] Later on, in 1893, Adam Poulsen, the Danish meteorologist, put forward the theory, based on his observation of the aurora borealis in Greenland, that the phenomenon is due to cathode rays. According to Poulsen's opinion these rays were formed in the upper strata of our atmosphere.

My deceased colleague, Professor Kristian Birkeland, however, by his series of remarkable experiments, was the first to give a reliable basis to the theory that the aurora borealis is caused by electric rays from the sun.

In 1896 he discovered the highly interesting effect of a magnetic pole on a beam of rays, viz: that of concentrating them to one point like the concentration of rays of light by a lens. This discovery suggested to his scientific mind the possibility that the earth, which is in reality a huge magnet, might in like manner concentrate cathode rays or similar electric rays from the sun, toward the southern and northern aurora borealis zones. Having adopted this suggestion, Birkeland tested it by decisive experiments.

In a large vacuum glass jar he suspended a small magnetic sphere, and directed the cathode rays toward it. This remarkable experiment was carried out in 1901.

While the sphere was still unmagnetized, the cathode rays touched only one-half of the sphere, upon which they distributed themselves like a uniform light, but as soon as the sphere was magnetized the phenomenon assumed a quite different character. The cathode rays distributed themselves in horn-like bundles of rays, the points of which touched two ring-shaped zones, one around each pole, and produced there illuminated patches distributed around these zones. Thus we obtained an experimental production of the belt of northern lights and the corresponding belt of southern lights. See Fig. 12.

Based on this experiment, and also on the results of his aurora borealis expedition in 1899-1900, Birkeland formulated his first aurora borealis theory, viz: that this phenomenon was the effect of secondary cathode rays, originating from vast systems of electric currents in the highest strata of the atmosphere, these systems of currents being formed by cathode rays from the sun.

Later on, however, he amended this theory in so far as he came to regard the aurora as directly caused by cathode rays from the sun. This new explanation of his was hinted at as a possibility in his treatise of 1901, and was further developed in the second part of his work, "The Norwegian Aurora Borealis Expedition, 1902-1903," which was completed in 1913.

About the beginning of the year 1903 I became deeply interested in Birkeland's remarkable experiments, and being a mathematician, I began to wonder whether it would be possible by purely mathematical methods to obtain not only the details of Birkeland's experiments, but even the essential characteristics of the nature of the aurora phenomena.

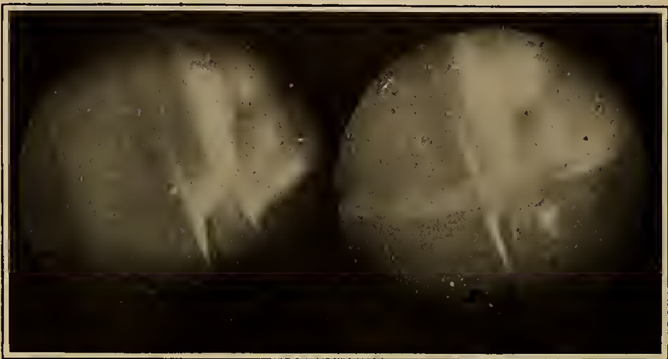


FIG. 8. PHOTOGRAPHS OF NORTHERN LIGHTS WITH PLANET VENUS IN THE BACKGROUND

Taken simultaneously from Bossekop and from Korsnes 27 kilometers north of Bossekop

I started at once to work at the problem, and my first results were published in a treatise in the year 1904. In this work I succeeded in pointing out theoretically several matters of importance: First an explanation was found of the fact that the auroras are generally confined to the Arctic and Antarctic zones, and also an indication of the possible explanation of aurora arcs and curtains. It was found that a beam of parallel cathode rays emanating from the sun and descending into the atmosphere was bound to become situated in a long

[3]Vegard has found that the Italian astronomer Donati had a similar idea in 1872.

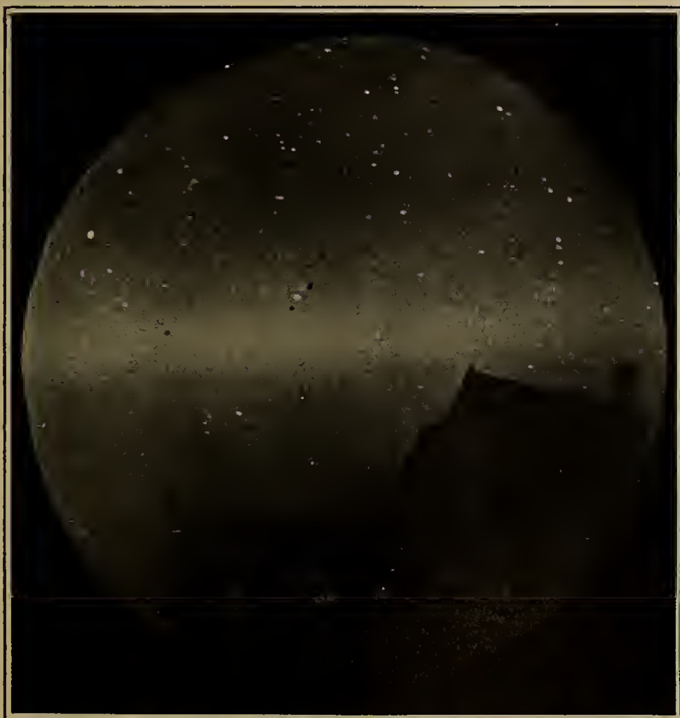


FIG. 9. AURORAL ARC PHOTOGRAPHED AT BYGDÖ ON THE NIGHT OF MARCH 7-8, 1918.

Perseur, Andromeda and Cassiopeia may be seen in the background

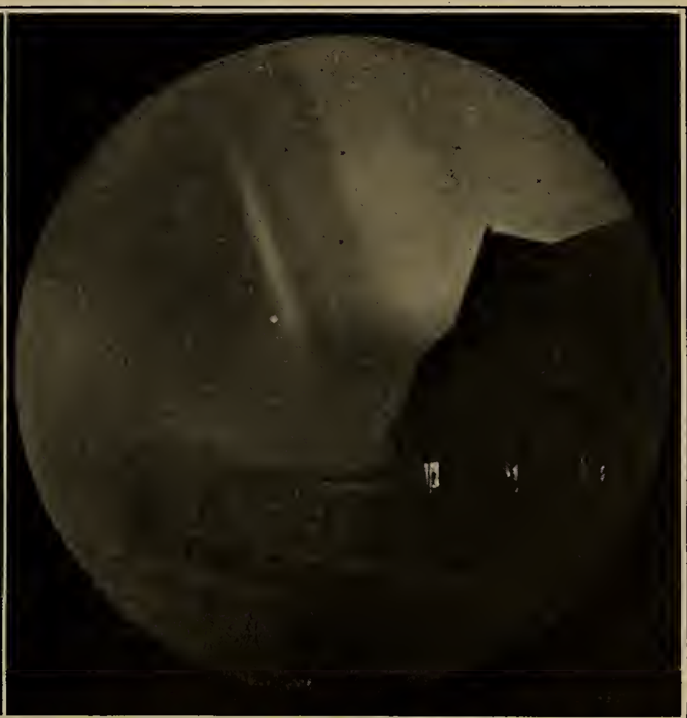


FIG. 10. AURORAL ARC PHOTOGRAPHED AT BYGDÖ ON THE SAME NIGHT

In the background may be seen the star Procyon

narrow area, limited by magnetic lines of force and extending in the direction of magnetic east-west. Rays diffused over this area would then cause arcs or curtains.

For further progress in this direction there was nothing left but a series of extensive calculations in order to integrate the differential equations of the problem numerically—as the technical phrase runs.

FIG. 11. AURORAL CORONA WITH THE GREAT BEAR IN THE BACKGROUND. TAKEN ON THE SAME NIGHT AS THE TWO PRECEDING

This vast undertaking was subsidized by the Nansen Fund, and extended over some years. In fact, the work absorbed something like 5,000 hours and a number of the students at Kristiania University have taken part in it from time to time.

I will endeavor to give a somewhat popular explanation of the objects in view.

The starting point of the theory was that electrically charged particles—the so-called corpuscles—emanate from the sun, and on their way through space approach the earth and are influenced by the latter. Thus the problem was to ascertain by calculation how this emanation of the corpuscle from the sun would have to take place in order that the corpuscle should hit the earth—and this calculation had to be performed for each and every position of the sun and the earth mutually.

The problem may be compared to that of calculating the trajectory of a cannon ball, the cannon being placed on the sun, the target being the earth, and the electrically charged corpuscle the ball. But the problem differs very much indeed from the simple trying of a new gun.

First of all the distance is immense. Fifteen million kilometers is so long a path that a cannon ball with a speed of 1,000 meters per second would need five years to travel the whole distance. To make up for this, however, the speed of the particle is very considerably greater than that of the cannon-ball, being several tens of thousands of kilometers per second: finally the projectile in our problem is infinitesimally small as compared with a cannon ball—measuring at the utmost a three-millionth part of a millimeter in diameter.

There is also another essential difference. The forces influencing the flying ball in a gun trial are gravity and the resistance of the air. In our problem, the corresponding influence is the effect of the earth's magnetism, because the particle is electrically charged. This influence is most peculiar, inasmuch as it does not check the speed of the particle, but consists only in a deflection at right angles to the direction of its path.

Higher mathematics, however, teach us how to master both problems. The trajectory may be found by careful calculation, and if we spend time freely the goal will at last be reached, though our progress be slow and our path uphill. In a popular article like the present I cannot specify in detail either the mathematical theory or the methods of calculation devised for the occasion, and I must content myself with showing the pictures of trajectory models.

We first calculated groups of trajectories from the sun corresponding to particles shot out in various directions toward the earth. The difficulty was to aim correctly so as to make the particle strike the earth. Most often we missed. The particle approached the earth but glanced off without hitting. Some few times the particle came fairly near, and approached the earth in a spiral path, coiling itself backward again without striking. At other times the particle would revolve round the earth far outside the path of the moon, later on returning inward in most remarkable loops.

In Fig. 13 we see a large cotton thread model of a series of trajectories. The earth is in the center, but I have made its size out of proportion. Several features are worth noticing. First note how the particles on the right side are flung sharply outward and upward and how those to the left side, the afternoon and night side, turn round the earth.

None of the trajectories here depicted reach the earth. It was not until it occurred to me to calculate backward from the earth to the sun, that at last we caught the trajectories that hit. More than 1,200 working hours were occupied in the exact calculation of these trajectories. You see some of them in Fig. 14.

A remarkable feature of these trajectories is the fact that they may turn round the earth and descend on the night side opposite the sun, corresponding to the fact that the aurora borealis may occur at night.

In Fig. 15 we see how well the calculations correspond with Birkeland's experiments. The places where the surface of the sphere has illuminated patches, agrees with the places of descent for the trajectories calculated.

By the aid of this mathematical theory a number of auroral phenomena are explicable, in particular, the formation and occurrence of the zones of aurora borealis and the characteristic arcs and draperies, also, the auroral rays and their direction. We cannot here enter into particulars,

FIG. 12. ILLUMINATION OF THE MAGNETIZED SPHERE PRODUCED BY CATHODE RAYS

To the right the sphere provided with a screen S indicates one of the magnetic poles

but must refer to the detailed report which is to be found published in "*Terrestrial Magnetism and Atmospheric Electricity*" for March and September, 1917, Washington.

Much still remains to be done. Thus in order to make clear the connection between magnetic storms and the aurora borealis, I showed, in 1911, that one effect of cosmic current systems of electric particles in the space around the earth, is

that they can draw the aurora southward, while at the same time magnetic storms are noticed all over the world.

Another problem is the path and illuminating effect of the rays during their passage down through the atmosphere. *That which we call the aurora borealis is precisely the light produced by the electric rays under the resistance of the atmosphere.* The calculations concerning this phenomenon have, as regards the straight paths, been carried out by Lenard, Vegard and myself. As regards the *curved paths* (corkscrew spirals round the magnetic lines of force) the calculations are far more difficult, but I have succeeded in carrying them out. A work of considerable size on this subject is at present being printed.[4] The results show that it is thereby possible to explain a series of new details regarding the aurora borealis and at the same time they give *information regarding the composition of the atmosphere at greater altitudes.* For the last question, however, a study of the spectrum of the aurora borealis at various altitudes will be of decisive importance, and this will be one of the great tasks of the future in auroral research.

FIG. 13. TRAJECTORIES APPROACHING A MAGNETIC SPHERE FROM BEHIND. RESULT OF MATHEMATICAL CALCULATIONS

For solar physics, too, auroral research will be of importance, for the electric rays emanate from the solar atmosphere, and will therefore be able to provide us with information concerning the physical condition of the sun.

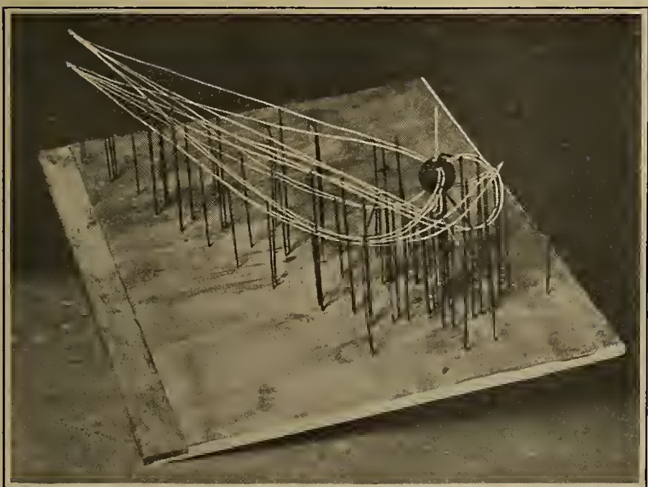


FIG. 14. SOME TRAJECTORIES HITTING THE AURORAL ZONES OF THE EARTH

[4]In *Geofysiske publikationer* (Christiania).

THE DISTRIBUTION OF LAND AND WATER

MR. H. F. REID presents in a recent number of the Proceedings of the American Philosophical Society an interesting paper on the Distribution of Land and Water on the Earth.

The shapes of the various continents and seas, their relative areas, and their dispositions with regard to each other, says Mr. Reid, have always been attractive problems for geographers; and a number of characteristics have been formulated.

1. The earth can be divided into two hemispheres in such a way that nearly all the land is concentrated in one hemisphere, and the other is nearly all covered with water.
2. The land is everywhere opposite the water.
3. The land is concentrated around the arctic regions, and the water around the antarctic regions. The land sends three projections southward and the oceans three northward.
4. The continents are roughly triangular in shape, pointing southward. The oceans are roughly triangular in shape, pointing northward.
5. The continents are divided into a northern and a southern group by mediterranean seas, and the southern group is offset toward the east.

The antipodal relation of land and water has been until recently, says Mr. Reid, an absorbing though baffling mystery, with no threads leading to its solution. But the matter turns out to be rather simple, after all. It can be shown that nearly all the characteristics enumerated above are comprised in the following: The land area of the earth is a loosely connected, and deeply dissected area, about five-sixths of which is concentrated in one hemisphere, whose pole lies about half way between the equator and the north geographic pole. And the position of this land area on the earth has no relation to the earth's equator and axis of rotation. So far as the antipodal relation of land and water is not explained by the existence of a land and a water hemisphere, it is purely accidental. Also, the suggestion of a triangular shape for the oceans and continents is too vague to have any meaning.

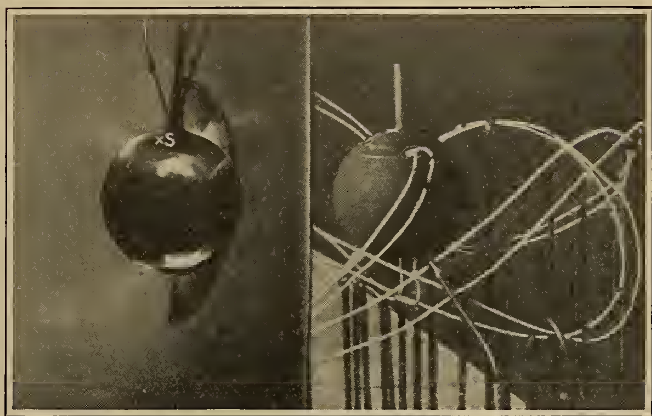


FIG. 15. REMARKABLE AGREEMENT BETWEEN THEORY AND EXPERIMENT

In regard to the question as to why there should be a land hemisphere and a water hemisphere, Mr. Reid says that the answer given by Herschel, about 60 years ago, is the true answer, namely, that the center of mass of the earth and its center of figure do not coincide.

In discussion of this view, Mr. Reid examines the views of such authorities as Hayford, George Darwin, Osmond Fisher, Dana Faye, Pratt, Lord Kelvin, Le Conte and Chamberlin. He concludes that there is to be found in common in their views or in the data which they use, the basis for the conclusion that the existence of a water hemisphere and a land hemisphere is due to the non-coincidence of the center of mass and the center of figure of the earth; that this is due to a difference of density in the two hemispheres, probably confined to a hundred miles or so of the surface; and that this, in turn, is due, not to unequal contraction but to a difference in the composition of the rock in the two areas.

Legendary Islands of the North Atlantic

The Mystery of the Islands of Atlantis and Brasil and Their Influence upon Columbus

By Albert A. Hopkins

Fellow of the American Geographical Society

"ATLANTIS" or "Atlantica" was described by Plato as lying just beyond the "Pillars of Hercules" (Straits of Gibralter). This legendary island, or fragment of continent which sank into the ocean, is inextricably wound up with folk-lore and the whole subject presents a very fascinating side of mythical geography. The present article without endorsing any particular set of views attempts to show certain interesting side lights on this and other mythical islands of the North Atlantic.

After the Renaissance with its renewal of interest in Platonic studies many attempts were made to rationalize the myth of Atlantis and even as late as the 17th and 18th centuries the credibility of the whole legend was seriously debated and sometimes admitted even by such men as Montaigne, Buffon and Voltaire.

A most valuable paper on this subject appeared in the little known Proceedings of the Royal Irish Academy, Vol. XXX, Section C, No. 8, written by T. J. Westropp, M.A.,[1] which contains matter of such general interest, for instance, the suggestion that Columbus was affected by these mystic isles and the repeated errors which survived until the middle of the last century, that the writer has condensed this long and scholarly paper, with its minute references, to a few thousand words. These islands are also called "*les îles fantastiques.*"

THE IRISH SEA-BELIEFS

The early inhabitants of Ireland, keenly intelligent, poetical, and with an unusual appreciation for natural beauty, stood on the western coasts face to face with phenomena of mystery and might. It is not wonderful that the great strength roaring beneath their cliff-forts and on the sandhills of their settlements deeply impressed them. Older races had bowed in awe before tamer seas; the Egyptian had feared the "great green one"; the Hebrew had seen God's path in those great waters, and had heard their hymns of praise or cries of deep anguish, when trouble was on the sea and it uttered its voice and raised its hands on high; the early Greeks had evolved from its waves and whirlpools the forms of the Sirens, Charybdis, and Scylla, with her barking waves; the tutor of Nero foretold the loosening of its bonds and the discovery of an unknown continent; while even in the deserts, far from its shores, the Arabian prophet pictured "black night on the deep, which wave on wave doth cover, cloud upon wave, gloom upon gloom." Much more so the Irish, on the outskirts of the known world, felt the wonder that we cannot shelter ourselves from, even by knowledge of natural laws; and their scholars were not unacquainted with what the Scriptures and the classics had to tell.

The coast-dwellers saw the mirage or the cloud-bank brooding on the water; to them it was a floating island,[2] possibly to be disenchanted. They saw the foam spring high out to sea, and strange reflections below the waves; it was a magic land that lay there, and the gold-roofed towers and domes glinted deep under the waters;[3] nay, it rose over the waters once in seven years, as men could attest. The ships of the Danaan and Sidh (demons and gods) sailed visible to all, reality and no mirage to the older tribes. The current suddenly foamed in a long tideway, or twisted and writhed; and to the onlookers it was clear that some vast monster swam or turned beneath it; while those lost at sea or in the surf, trying to land, were devoured (thought the survivors) by monsters. The Irish, of course, had no monopoly of such views. Even at the end of the sixteenth century Hakluyt contradicted those who said that the currents "bee swallowed by and cast up againe by the breathing of Demogorgon." The Irish went farther; they regarded the waves as sentient prophetic beings, for, in oldest Irish writers, "the great waves of

LEGENDARY ISLANDS IN THE VICINITY OF IRELAND

Erin"—Rudhraigh, Cliodhna, and Tuath—raised their deep voices to foretell disaster and crime, and the wave of Malbay mourned for the death of Keane of Ross, so late in the reign of George II.

In the center of all this weird mystery the pagan Irish placed their heaven, the "Land of Youth," the "Land of the Living," with so firm a belief that, even when they adopted a faith in whose paradise "there was no more sea," they brought their belief along with them.[4] Devout Christian writers rendered "Tir Tairngiri" as the "Land of Promise" and the "Kingdom of Heaven" in notes on the Epistles to the

[1]A book entitled "Legendary Islands of the Atlantic," by William H. Babcock will be published shortly by the American Geographical Society as a monograph in their Research Series. It will contain interesting maps and will be a scholarly contribution to an interesting subject. See also "The Island of the Seven Cities" by the same author. *Geog. Review*, Feb., 1919.

[2]So also on the opposite shore of the Old World the Chinese had legends of "Isles of the Blessed," 700 miles eastward in the Yellow Sea; places of everlasting spring, gladness and beauty. Their secret was revealed to the Emperor Tshe Huan Ti about B.C. 219. Youths went out to find the Isle, and saw it in roseate light on the horizon, but storms drove them away. Similar stories are told in Japan of the happy isle of Oraison, far out to sea.—Nansen, "In Northern Mists."

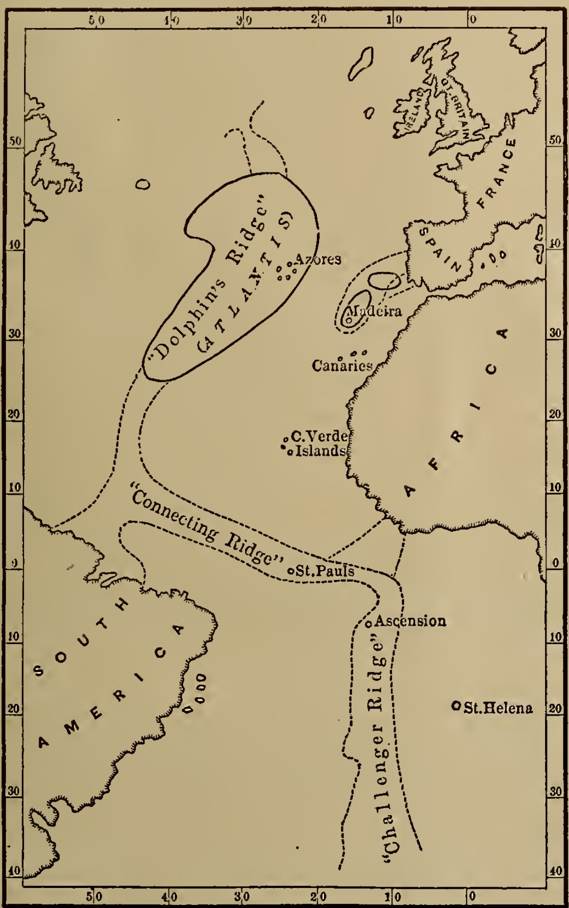
[3]"Voyages," Vol. II, p. 9.

[4]Those who held that Eden lay eastward were met (both by those who held that the earth was spherical and those who held it was flat) by the argument that Asia reached around to opposite Europe, so that the farthest east was near the west shores of Ireland.

Corinthians and the Hebrews; the blending was complete and lasting; "Magh Mell of many flowers" was the "Land of Truth," the "Land of the Promise of the Blessed," "whose truth was sung without falsehood." This, however, was equally the "Land of Fair Women," fitter for Islam than for "the Faith"; to this Isle, Connla, King Conn's son, was lured by the woman of the fairy mound. The island was not alone in the deep; "thrice fifty isles" as large as, or "twice and thrice" larger than, Erin, "were counted"; many of these figure in the Voyages of Brendan and elsewhere. The classics were brought into unison with this belief, as the Psalms had been; and we hear of the Hesperides to the west of Aran, "where the sun goes to his couch." The kindred races in Britain doubtless contributed their quota.

EARLY SEA-TALES

The early Gael loved sea-tales. How many of these were lost in the wreck of Irish literature we may never know; some may even yet be recovered, but no less than five have reached



MAP OF ATLANTIS WITH ITS ISLANDS AND CONNECTING RIDGES AS SHOWN BY DEEP SEA SOUNDINGS. FROM DONNELLY'S "ATLANTIS"

us, so we can form a good idea of the Irish belief about the outer sea. Plato's description of Atlantis is closely similar and may have become known through some Greek-reading cleric. The same seems true of Lucian's "True History." The affinities to the sagas of Ulysses, Æneas, and Sindbad of the sea are striking. The legends very probably date from the ninth century to the end of the eleventh, the earliest manuscript of "Maelduin" being just before 1100, while one of "Brendan" is alleged to be of the ninth century. St. Brendan's *Navigatio* had widespread influence on Italian thought, and are among the ancestors of the great Florentine epic. The lesser stories had little influence; but how far the *Navigatio* of Brendan reacted on Dante and the fifteenth century explorers can hardly be estimated.

Space will not permit of including a résumé of all the Irish root sea-tales, so we will pass on to the greatest sea-tale of Brendan,[5] which is called the "*Navigatio.*" It exists in various stages and is possibly a ninth-century sermon elaborated up to its present form by the eleventh century. It was known in some form to the Arabian geographers in Spain about 1150. It spread beyond Ireland among the Normans, being translated for King Henry Beauclerc and his wife; and the Anglo-Norman Conquest spread it more and more. It passed to the Portuguese, and probably stimulated the designs of Prince Henry the Navigator, and a little later those of Columbus. It was a source of Dante's great poem. What truth lies behind it is difficult to guess. Matter-of-fact writers have treated it as a genuine log-book; but poets have more truly seen in it a revelation of great symbolic beauty. It is more than probable that St. Brendan (like SS. Columba, Colman, and Flannan) was actually a daring voyager; and that in some lost "Life," his actual visits to various islands were told. We are less concerned with the actual facts than with the stories that so impressed the world. Columbus was in touch not only with the Portuguese, but with Bristol, the merchants of which sent seven expeditions to search for "Brasil" before the fifteenth century ended. He also had at least one Irish sailor with him on the great voyage of 1492; from any or all of these he may have heard the Brendan legends.

THE MOST FAMOUS OF THE PHANTOM ISLANDS

"Brasil" or "Brazil" takes a prominent place in the early maps of Italy, Spain, France, and even England and Germany. Its name is obscure; some say it is from the Irish "Bres," noble, or, as Nansen says, "fortunate." It was clearly brought about in prehistoric times by mirage and fog-bank. The setting sun and the place of the dead helped its religious significance; it became the "Isle of the Living," the "Isle of Truth," the "Isle of Joy," the "Isle of Fair Women," the "Isle of Apples," "an Eden, away, far away." Christianity, trustee to dead Paganism, made it the "Land of Promise." Then the belief materialized before commerce, and it became (as Sir David Wilson writes[6]) "an imaginary island of Brasil that flitted about the maps of the fourteenth and fifteenth centuries with ever-varying site and proportion, till it vanished. It was not a reef or a shoal, but a mist or mirage 'sprung from the sea without root'; but it held its place on the charts from 1320 to 1865, and was said to have been seen at close quarters in 1791."

COLUMBUS AND THE MYTHIC ISLANDS

This is no place for any elaborate study of the most interesting question relating to the mythic islands, namely, how far the belief in them affected the discovery of Columbus. A few notes must suffice. It will be remembered that Christopher Columbus based his great enterprise on three errors—the extension of Asia so far eastward as to reach within a comparatively short distance from the west of Europe; the inaccurately small circumference of the world; and the existence of large islands in mid-ocean. The maps of two centuries and the traditions known to him bore out the last item. The Spaniards believed so firmly in the Isle of the Seven Cities that they actually inserted a clause in the Treaty of Evora with Portugal, reserving "the islands which had not been found," and the people of the Canaries also petitioned to be allowed to annex it. Columbus, as his son Ferdinand records, knew of Seneca's future continent and of Aristotle's *Antilia.* This almost certainly implies knowledge of the Atlantis legend. He gathered all he could learn of these and of St. Borondon's Isle, and the Seven Cities. He had heard of Antonio Leone (or Leme) reaching an island 100 leagues west from Madeira, of two floating islands, more to the south-west, mentioned by Juventius Fortunatus, and of a Madeiran asking for a caravel in which to seek for Antilla. Peter Velasques, a pilot, told Columbus at La Rabida how, in the time

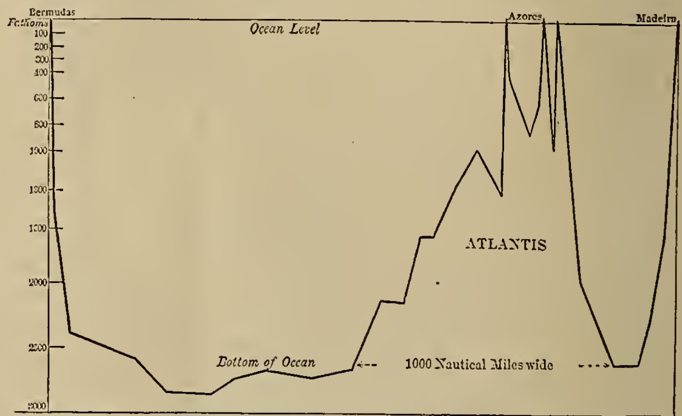
[5]The literature on this subject is large. Consult Rev. S. Baring Gould, "Curious Myths of the Middle Ages."
[6]"The Lost Atlantis," 1892.

of Prince Henry, his Master (born 1394, died 1460), James de Fine, going from Fayal to Cape Clear, in Ireland, about 1450, got under shelter of an unknown isle to the west of Ireland. Peter Velasques, of Galicia, confirmed this of his own knowledge, and Columbus had a letter of Vincent Dea, a Portuguese, telling how he had seen an island beyond Madeira. The great explorer went northward, heard what the Bristol merchants (indefatigable seekers for Brasil) had to tell, and in February, 1477, sailed 100 leagues beyond Thile (Ireland). There, if the passage be not an interpolation, he may well have seen manuscripts such as exist, dated fifty to seventy years before his visit, telling, in matter-of-fact words, of Greenland, Helluland, Markland, and Vinland (the last "stretching toward Africa"), with wide channels between, and manuals are often more convincing than folios. He was in touch with Galway, the center of Irish lore of Hy Brasil, for he included among his sailors in 1492 William Irez, of Galway, in Ireland. He cites religious legends for accounts of the wonderful birds and plants of the ocean islands. He fully expected to meet such islands on his way to Cipango, Cathay, and the Indies; what he did not expect was to be walled off from Asia by a vast continent. The belief in the islands must have been of the first importance to encourage him and his men on their daring voyage when they burst into the silent sea.

ATLANTIS AND OTHER LOST LANDS

Though it has not been demonstrated that Plato's[7] descriptions of Atlantis were known to the Irish, the probability is considerable. Seneca's works were actually in the Library of the great Hiberno-Italian school of Bobbio, while St. Gall had another famous early library to which scholars (and perhaps monastic redactors of the Brendan Saga) would most likely have resorted. This is no place to go deeply into the question as to whether Plato actually heard a genuine legend of Egyptian priests from the time of Solon, and if so how an alleged historic event of B.C. 9600 could have been handed down even to the Egyptians of the early dynasties 5,000 years later. The point which concerns us is the unmistakable likeness of the mythical Atlantis to the islands seen by the Irish writings concerning Bran, Maelduin, and Brendan. As in "Bran," where the sea-god Manannan is father of Mongan by an Irish princess, so, in Atlantis, his equivalent, Poseidon, has ten sons by mortal mothers. Atlantis has a marvellous fort with rings of three fosses and two walls of bronze, tin, and *aurichalchon* or red copper; so, in the legends of Maelduin and Hui Corra, is the ring-fort with brazen rampart, palisade, and bridge over a wet fosse. Atlantis was walled all round, so are the Irish legendary isles. In both we hear of wonderful temples and altars, founts of hot and cold water, well-planted groves and a wonderful race course; the parallel is close indeed, whatever degree of connexion there may be between them. Atlantis is said to have lain outside the Straits of Gibraltar, to have been as large as Asia (Minor) and Lybia combined, and, after overrunning all the Mediterranean shores to Tyrrhenia and Egypt, its armies were checked by Athens; eventually it sank in a day and a night during an earthquake, and was entirely submerged by the sea, leaving dangerous shoals. The resemblances between Lucian's "True History" and the Irish tales are most striking.

The Atlantis legend reached the Arabian geographers along with the Irish and Norse tales. The Arabs were believed to have crossed the Atlantic; and the Observatory of Sagres, under the influence of Prince Henry the Navigator, collected all records of voyages, with the result that Madeira was rediscovered (or discovered if the alleged Bristol settler be mythic), and the voyages commenced which at last doubled the Cape of Good Hope. The nearest neighbors of the early Irish were not without similar beliefs. The Britons believed in the elusive Isle of Avalon. The Welsh, too, had their great lost land sunk by a drunken, careless prince. There was also the lost land of Lyoness, or Lennoys, of which the Scilly Isles are said to be the last remnants. Florence of Worcester (died 1118) tells of its flourishing condition and how it sank, like Atlantis, beneath the waves. It, like Avalon, was never placed on the early maps, and there is no evidence that it affected either the Irish or Iberian beliefs, though it secured a place in English literature through Tennyson and Swinburne. Scotland, too, had her "Flaith Inis," which was surrounded by clouds and tempests, with an island, "Caerecennfinn," between Scotland and Ireland, where the Irish of Ulster placed their "Tir Hudi." The Bretons had their submerged city of Is; the French and Portuguese told of the mythic Isles of Maida, Asmaida, or Asmanda and Isle of Verte, Ilha Verde, suggesting the Inis Glas of other legends. The Spaniards had their tale of Antilia and the Isle of the Seven Cities of the Gothic kings and bishops who fled from the Moors to them in 714, while Ireland, England, France, Portugal, and Spain agreed in believing that outside human trade, rarely within the limits of sight, lay Brasil and St. Brendan's Isle, the Fortunate Islands, the Isle of Birds, and the Isle of Sheep. The reader who is interested in Atlantis and who wishes to carry on further reading can consult the best authority, Pierre Termier. "Atlantis" in the Annual Report of the Smithsonian Institution for 1915, pp. 219-234. This translation is more accessible than the original paper



PROFILE OF "ATLANTIS" AS DETERMINED BY "CHALLENGER" AND "DOLPHIN" SOUNDINGS. FROM DONNELLY'S "ATLANTIS"

which appeared in the *Bull. de l'Inst. Océanogr.* No. 256, Monaco, 1913. At the request of the American Geographical Society this brilliant paper was reviewed in their journal, the *Geographical Review*, for January, 1917, by Dr. Rudolph Schuller, formerly of Para, and Prof. Charles Schuchert of Yale.

In the early eighties Ignatius Donnelly, a prominent thinker of the time, presented what will probably remain the best brief for the existence of this remnant of a continent called "Atlantis," in a book which is a marvel of logic, called "Atlantis: The Antediluvian World." This work set out to demonstrate several distinct and novel propositions. These are:

1. That there once existed in the Atlantic Ocean, opposite the mouth of the Mediterranean Sea, a large island, which was the remnant of an Atlantic continent, and known to the ancient world as Atlantis.

2. That the description of this island given by Plato is not, as has been long supposed, fable, but veritable history.

3. That Atlantis was the region where man first rose from a state of barbarism to civilization.

4. That it became, in the course of ages, a populous and mighty nation, from whose overflowings the shores of the Gulf of Mexico, the Mississippi River, the Amazon, the Pacific coast of South America, the Mediterranean, the west coast of Europe and Africa, the Baltic, the Black Sea, and the Caspian were populated by civilized nations.

5. That it was the true antediluvian world; the Garden of

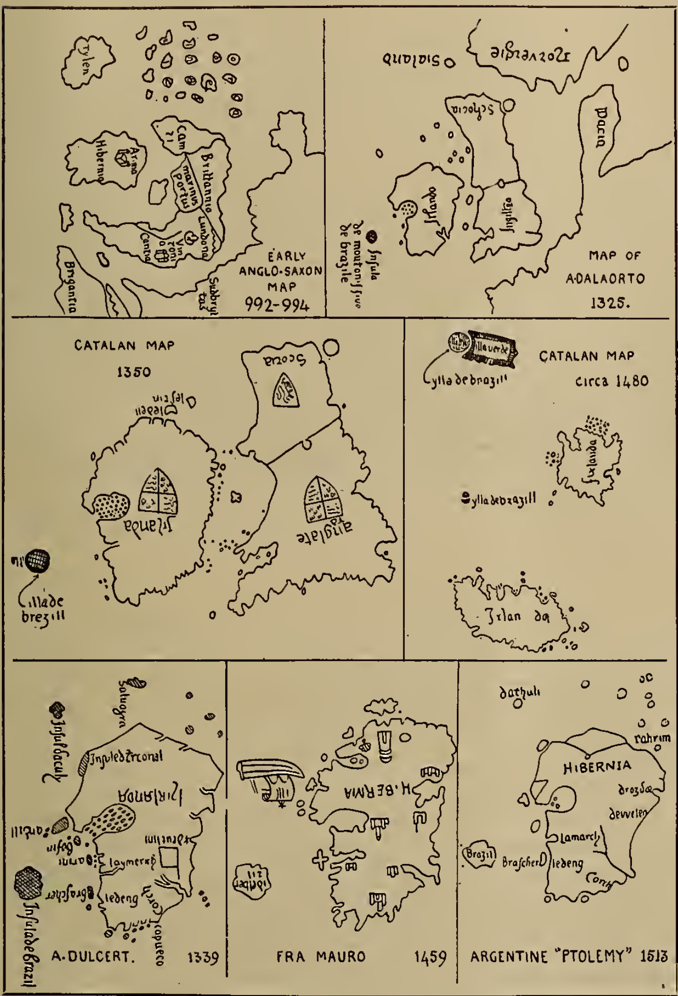
[7] Plato, "Timaeus" VI.; and "Critias III. VIII. XV. See also Dr. Robert F. Sharff's paper, "Proceedings of the Royal Irish Academy, Vol. XXIV. Section B., Part III.

Eden; the Gardens of the Hesperides; the Elysian Fields; the Gardens of Alcinous; the Mesomphalos; the Olympos; the Asgard of the traditions of the ancient nations; representing a universal memory of a great land, where early mankind dwelt for ages in peace and happiness.

6. That the gods and goddesses of the ancient Greeks, the Phoenicians, the Hindoos, and the Scandinavians were simply the kings, queens, and heroes of Atlantis; and the acts attributed to them in mythology are a confused recollection of real historical events.

7. That the mythology of Egypt and Peru represented the original religion of Atlantis, which was sun-worship.

8. That the oldest colony formed by the Atlanteans was



EARLY MAPS SHOWING "BRASIL" ISLAND

The maps are properly ornamentated although many of the letterings and symbols are inverted. Many place names have also been omitted in the interests of clarity.

probably in Egypt, whose civilization was a reproduction of that of the Atlantic island.

9. That the implements of the "Bronze Age" of Europe were derived from Atlantis. The Atlanteans were also the first manufacturers of iron.

10. That the Phoenician alphabet, parent of all the European alphabets, was derived from an Atlantis alphabet, which was also conveyed from Atlantis to the Mayas of Central America.

11. That Atlantis was the original seat of the Aryan or Indo-European family of nations, as well as the Semitic peoples, and possibly also of the Turanian races.

12. That Atlantis perished in a terrible convulsion of nature, in which the whole island sunk into the ocean, with nearly all its inhabitants.

13. That a few persons escaped in ships and on rafts, and carried to the nations east and west the tidings of the appalling catastrophe, which has survived to our own time in the Flood and Deluge legends of the different nations of the old and new worlds.

THE MYTHICAL ISLANDS IN EARLY MAPS

Interest in the islands of the Atlantic hardly existed before the twelfth century among the map-makers. The "Life of St. Brendan" had been spreading over the Continent for over a century before it began to affect the maps. Apart from his works there is no certain trace in the other maps of the imaginary isles till Dulcert in 1325 to 1339. These charts founded on experience and, as their name implied, showing the route from port to port, avoided the conventional, and strove to draw information from every source. The island corresponding to Brasil is also found in the Venetian map of 1367 and the far superior Catalan map of 1373, which marks a large circular island "Insula Berzil," in the same place, west from the Shannon, as also St. Brendan's Isle and Mam to the south of Brasil. It will be remembered that the compass was apparently known in the thirteenth century to Roger Bacon, and later to Dante's tutor, Brunetto Latini; but the latter says that sailors would not have it on board, regarding it as "an infernal spirit." It only became popular about 1360, so that its use, the making of the early maps, and the "appearance" of Brasil, all seem to be contemporaneous. The I. de Brazil is shown among the Azores, and a nameless isle, the mythic "Brazil," to the west of Ireland in the Venetian map of Andrea Bianco in 1436. One of the finest maps before Columbus, that of Frau Mauro, in 1459, identified Brasil with the Fortunate Islands. Mauro was known as the "*Cosmographus incomparabilis*"; he was a Venetian friar, and a medal was struck in his honor. To the fifteenth century belongs a Catalan compass chart; it marks "Ylle de brazill" a double island and (twice as far from Irlanda as it) another Brazill to the west of it, Ille Verde, and still further to the north "Fixland," apparently Iceland. In the very year when Columbus first reached the islands of America, Martin Behaim (or Bohemus) of Nürnburg made his famous globe. It shows Brasil and St. Brendan's Isle, the latter half-way between Ireland and Japan, in 1492.

If interest in geography was getting so keen and bearing fruit in the Portuguese expeditions down the coast of Africa, and the Spanish ones to the West Indies, it might be expected that it grew keener than ever after the great turning-point in history of that year, when "Columbus gave a New World to Castile and Leon." Two names passed from mythic and half-mythic islands; "Brazil" and "Antilia" attached themselves to actual countries; but though Antilia passed from the map of the Old World, Brasil still held its own off the Irish coast, though its name had been transferred to the land of the giant river and forests, greater and more beautiful than bard or monk had ever fancied.

England, having so narrowly lost her chance of being patron to Columbus, was now taking her place among the world-explorers. In August, 1497, the minister of the Duke of Milan wrote to his master from England to say that Cabot had found two large and fertile islands, San Juan and Prima Vista, and had found the "Seven Cities," 400 leagues from England. Eleven months later the Spanish Ambassador in London wrote to Ferdinand and Isabella, telling of Cabot's discoveries and second expedition, and telling how "the men of Bristol have, for the last seven years" (since 1492), "sent every year, two, three, or four caravels to search for the Isle of Brasil and the Seven Cities." Next year, 1499, the real Brazil was discovered.

The increasing traffic with America in the sixteenth century might have been supposed to have swept all the mythic tales into the "Never-Never Land," whence they had come; but this was not the case; and we must see how for some three centuries the islands held their own, while, perhaps, the earliest and latest of the group, Brasil and Buss, were found on maps till past the middle of the nineteenth century. In 1598 and 1599, Hakluyt gives Iceland,[8] with Frisland, half way between

[8] "Voyages," 1599, Vol. II., p. 33.

it and Estotiland. Not content with this, he collects a circumstantial report of the finding of Buss, the latest mythic island of the North Atlantic, and which (with Brasil, the earliest to find place on the maps) held its own down to very recent times. The most interesting section of the map-history of Brasil and its sister isles ends with the sixteenth century. A few instances are given in the original paper to show the continuity of the belief. Estotiland, St. Brandon's Isle, and Antilla, do not appear in any map after 1700, as far as Mr. Westropp knows; Brasil, Buss and Maida survived. Brasil is in Jeffrey's American Atlas in the year 1776 in longitude 17°35′ west, and lying west from Cape Clear. St. Brendan's Isle is also given. Buss was only eliminated in 1850. Brasil was finally removed from the charts so late as 1865. John Purdy's general chart of the Atlantic (corrected in 1830) says that the Brasil Rock was high and was fixed at 51°30′ west. In a chart of currents in A. Findlay's edition of "Purdy," and in the "Memoir, Description, and Explanation of the North Atlantic Ocean" we read "Brasil Rock, lat. 51°10′, long. 16°" M. Bellin in 1742 states that this rock is "marked in lat. 51°10′, long. 19°30′ Paris." Its existence has been doubted by Messrs. Verdun and Border. "It was, however, seen in the year 1791 by the company and master of an English merchant ship, the commander of which favoured the world with a description of it, stating that it is really a high rock, or islet, and by which he passed so near that he could have 'cast a biscuit on shore.' We suspect that if it exists it is more to the westward." Findlay's doubts increased, and he eliminated Brasil finally in 1865, after it had held its place for over 550 years on the maps. Local histories assert that the Channel Isles were connected with France up to 709, and that when St. Lo visited Jersey on inspection in 565 he could cross into it by a plank.

CONCLUSIONS AS TO THE LEGENDARY ISLANDS

Mr. Westropp sums up his conclusions, leaving to scientific men the questions of subsidence and the formation of the ocean-beds, which some have put back to the dateless Miocene:

1. The outer isles, Brasil, Brendan's and Ailbe's, are purely mythical, or, at best, based on mirage and fog-bank. This may be modified, should it be proved that the Porcupine Bank (which so closely corresponds in position with Brasil) has been above water even in an early human period.

2. The traditional islands along the coast, which are represented by actual reefs, were very probably actual islands down to a late period. The case of Mutton Island, split into three parts between 799 and 803, shows that the deep hollows now found between the fragments belong to merely 1100 years of denudation.

3. Of folk-lore, the power of fire to disenchant and fix firmly any phantom island is a cardinal article of belief; so is the appearance of these lands at intervals of seven years.

4. Some islands, though possibly none in these coasts, may have been upheaved and sunk by some volcanic outburst. Very possibly some such event originated the tradition of the vast continent sunk in the waves of which Plato told.

It is probable that red dye woods used in the Middle Ages were connected with Brasil, the mythical and that the familiar existence of "Brasil" as a geographical name led to its bestowal upon the vast region of South America, which was found to supply dye-woods kindred to those which the name denoted.

OCEANIC CURRENTS AND DENSITY OF WATER

STUDIES by M. J. Thoulet concerning ocean currents and density recently formed the subject of a paper read by the Prince of Monaco before the French Academy of Sciences at the session held April 4, 1921. An abstract of this taken from *Le Génie Civil* (Paris) for April 16, 1921, is given below:

Marine currents are the result of an infinite number of causes which vary greatly with regard to their importance. Chief among these are the wind, the rotation of the earth and the two antagonistic effects of heat, which on the one hand causes the water to expand and thus make it lighter, while on the other hand it produces evaporation, thus increasing the concentration and making it heavier.

The latter two influences are characterized by a single variable, the density *in situ*, *i.e.*, the weight of a cubic decimeter of water under given conditions of temperature, salinity, and even of *pressure* when the specimen examined is taken from deep waters—or when it exerted an influence in nature such as forms the subject of the following experiments:

Since the density *in situ* gives the total amount of the algebraic addition, it is important to guard against any separation of the two factors concerned, temperature and salinity. Regarded from the point of view of its density *in situ* the sample is, so to say, *living*, while its normal density at zero characterizes its *dead* state, *i.e.*, when contained in a bottle in order to be compared with other bottled samples. The object to be attained, therefore, is the prompt and precise estimation of the density *in situ*, by an easily applied process, of samples procured simultaneously at various points on or below the surface, in the same current, making use of as small quantities as possible when the sample is taken from deep water.

These requirements are conveniently met by the use of an indirect method of measurement. This consists in finding at first, at the surrounding temperature, the index of refraction of the sample by means of a suitable refractometer (the best one for this purpose is the Abbe instrument, especially the model called the *plunger*), and then making use of this datum by means of special graphic tables, to find the value of the density *in situ*, and then, if it be judged necessary, the values of the normal density, the degree of salinity and the amount of chlorine contained.

The entire operation takes only a few minutes and furnishes the density sought with an approximation of only 1 or 2 units of the fourth decimal. The address concluded by a statement of the data found in this manner.

CHEMISTRY OF THE EARTH'S CRUST

IN an article published in the *Journal* of the Franklin Institute (December, 1920, pp. 757-815) H. S. Washington gives tables showing the distribution of igneous and sedimentary rocks in the crust of the earth, the latest estimates of the composition of the crust, and the relative amounts of the elements. The elements are referred to two main groups of the periodic table: (1) The petrogenic elements, characteristic of and most abundant in the igneous rocks, are of low atomic weight and occur normally as silicates, oxides, chlorides, and fluorides. (2) The metallogenic elements, rare or absent in igneous rocks, but occurring as ores of high atomic weight, and forming "native" metals, sulphides, arsenides, etc., but not primarily silicates. In igneous rocks and minerals the elements show a correlation, in that some of them are prone to occur with others. Moreover, the igneous rocks themselves occur in regions where they are chemically related—called "comagmatic regions" in America and "petrographic provinces" in England. The calculation of rock densities from their chemical composition is discussed, and the results are shown to confirm the theory of isostasy.

Earth's Interior.—Knowledge regarding the earth's interior is summarized. It is essentially a rigid solid; hot, with the temperature increasing toward the center at a variable but unknown rate. Its mean density is about twice that of the crust. It acts as a magnet, and since the surface rocks are not very magnetic, this character may be attributed to its interior materials. The center of the earth from about half the radius is composed of different materials, is of high density, and does not transmit torsional vibrations. The density cannot be accounted for by compression. The suggestion is made that below the silicate crust is a zone essentially of nickel-iron, and beneath this a central core of metallogenic elements. This agrees with the magnetism and density of the earth, and with Abbott's views as to the distribution of elements in the sun.—From *Science Abstracts.*

SUNRISE ON THE HIMALAYAS, "THE ROOF OF THE WORLD"

The World's Greatest Adventure

The Ascent of Mt. Everest as a Test for Human Endurance

By H. Snowden Sinclair, A.M.

THERE are few worlds left to the explorer to conquer. The poles have lost their mystery; there is little sport in tracing the head waters of a mighty or unknown river; but there remains one more feat to be accomplished—the climbing of Mount Everest, "the dome of the world." As we write, somewhere in the tangled maze of the southern Himalayan Mountains three parties of British engineers are working their way through unexplored gorges and passes toward the base of Mount Everest. They are blazing the way for the expedition that will later this summer attempt to scale the granite walls of Everest and conquer the highest mountain peak on the globe.

The first party to leave Darjeeling was commanded by Major Morshead, which proceeded up the Teesta Valley and over what is known as the Kangrila route. The other two units, commanded by Col. Bury, intend to meet the Morshead party at Khamba Jong, and then the combined expedition will strike westward toward the village of Tingri Jong, which is about thirty miles north of the Everest group. A permanent base will be selected near that village, and from it will start the party which will try to reach the summit of the dominating peak of the range. Before the actual work of scaling the stupendous slopes of Everest can begin, however, engineers must carefully survey all approaches to the mountain and try to find the most practicable route to the top. This reconnaissance work is the chief task assigned the men now working their way into the heart of the mountains.

The world's highest ground—or snow—rises 29,141 feet above sea level, and dominates a vast array of mountains which form the national boundary between Nepaul and Tibet. The great virgin summit is wreathed in eternal snow. Its supporting bastions are sheathed in ice and bulwarked by huge precipices, where monster avalanches thunder and roar, while fierce storms wage unceasing war on the earth's uttermost stronghold. At first sight it seems like a gamble against Fate, with human life as the stake, for man to attempt the conquest. Yet these grim terrors and the added difficulties of mere existence on the real roof of the world but increase the keenness to these sporting Britons who hope to plant their flag on the summit. At the outset the odds will be on the side of the mountain; but pluck and skill will prevail. Mr. George D. Abraham, an accomplished writer on Alpine subjects, writing in *The Illustrated London News*, fixes five years as the shortest possible time for final success, but the explorers themselves hope their efforts will be crowned by success in 1922.

FORMER ATTEMPTS

Up to the present, entry into the Forbidden Land has been impossible for political reasons: but the Indian Government has made arrangements to permit the passage of the expedition to the base of the mountain. "Jomo Kang Kar," or "Our Lady of the Snows," is an object of reverence and worship by the natives, and they may resent the intrusion of white men on their lofty shrine. The expedition is organized and financed by the Alpine Club and the Royal Geographical Society, and Sir Francis Younghusband, president of the latter society, has been very much interested in the subject since his remarkable expedition to Tibet in 1904.

There have been several former expeditions to other parts of the Himalayas, and most of them have had trouble with the natives. As long ago as the years 1854-1858 some very remarkable climbs were made by the two brothers, Adolf and Robert Schlagentweib, who reached a height of 22,259 feet on the great peak of Kamet (25,443 feet). After this Adolf crossed the Karakoram Pass, and was murdered at Kashgar. Then, in 1895, the attack on Nanga Parbat by A. F. Mummery came to a mysterious end. At the base of this magnificent icy obelisk the climbers divided. The leader of the party, with two natives, was to cross a short pass from the west to the north side of the mountain, and meet the main part of the expedition which had traveled round by a longer route. After bidding farewell to his friends, Mummery and his companions were never seen again. No trace was ever found, says Mr. Abraham. Those who knew the skill of the greatest of British mountaineers cannot believe that an avalanche caused disaster. Yet these monster mountain falls will prove one of the greatest dangers to the forthcoming expedition. Everything is on an immense scale in the Himalaya. Crevasses are thousands of feet deep. A simple snow-slide in Scotland, or an Alpine avalanche, becomes on the roof of the world a tremendous cataclysm, which shakes the greatest mountain to its very base, and which may be heard, or even felt, fifty miles away. A more insidious risk lies in the smaller avalanche started by human agency. One attempt on Kangchenjunga (28,150 feet), the third highest known peak, ended in tragedy. From a camp 20,343 feet high a section of the party decided to descend on account of a difference of opinion. Three amateurs and three coolies were crossing a snow-covered slope when two coolies on the middle of the rope slipped, peeling the loose snow off with them. In an instant all were carried off their feet and flung down the icy slope, a veritable human avalanche. Two Continental climbers were the only survivors. The four bodies were not recovered until three days later. They were buried under twelve feet of solid snow.

The expedition to Mount Everest will find that serious rock-climbing is encountered before the valleys are left behind, but they will be well equipped with skill and knowledge to meet all contingencies, as far as is humanly possible. The real test will come when the 20,000-foot level is gained. Even before this, that grim enemy, mountain sickness, will have sorted out the weaklings, and, gradually, only the soundest will remain at the loftier camps. In this connection we quote as follows from *The Alpine Journal* for March, 1921, the writer being Prof. J. N. Collie, a well-qualified expert:

MOUNT EVEREST WHICH TOWERS 29,140 FEET ABOVE SEA LEVEL

This is one of the few genuine photographs of this famous mount.

PHYSIOLOGICAL DIFFICULTIES

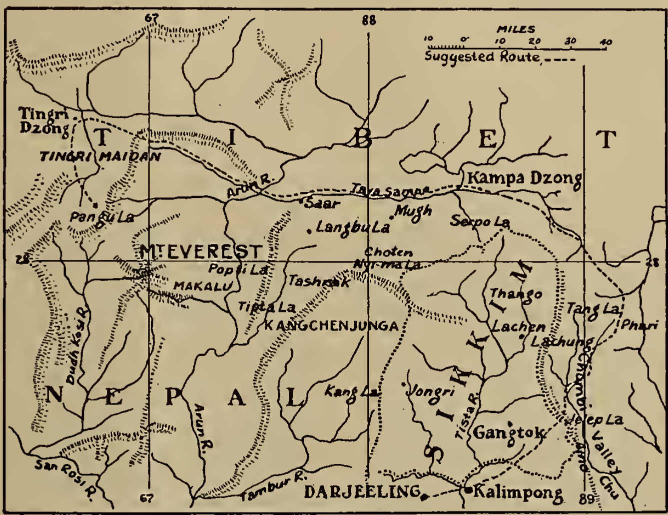
"It is the physiological difficulties, however, that play far the largest prohibitive part in high ascents. We yet have much to learn about them. The lack of oxygen and the effect of intense cold are the two chief difficulties to be conquered. The lack of oxygen at high altitudes is of course due to the rarefied air. During respiration the body gets its oxygen through the ultimate ramifications of the lungs—the alveoli; and it is through them that the blood becomes oxygenated before it returns to the heart, ultimately to do its work of oxidation of the tissues of the body. Should there be a deficiency of oxygen the natural processes of the body are at once interfered with. If one takes an engine, and in one hour burns in it a hundredweight of coal, we get a certain amount of energy produced. But if for one hour we cut off the supply of air so that only one-third of the coal is burnt we naturally only get one-third of the energy.

"On the summit of Mt. Everest one is supplied with only one-third of the usual amount of oxygen. The question is, Can the human engine do much work with this limited supply? Fortunately the body can acclimatize itself to a considerable extent to changed conditions. For instance, people who ascend Pike's Peak, 14,109 feet, in the United States by railway suffer from faintness, sickness and blueness of the lips and cheeks, breathlessness and general lassitude. Their blood is unacclimatized to the deficiency of oxygen. Yet on the Pamirs at 15,000 feet and above, people live their lives comfortably and do hard work; they are acclimatized. The chief effort of the body to counteract the deficiency of oxygen is to increase rapidly the number of blood corpuscles. These corpuscles are the carriers of oxygen from the air to the interior of the body. Double the number of these little carriers in one drop of blood, and that drop will carry twice as much oxygen to the tissues for available energy and life.

"The number of such corpuscles in a cubic millimeter of the blood of a person at sea level is usually less than five million. The average count of a native of the Pamirs is over eight million. On the Pamirs there is only about half as much oxygen in a cubic foot of air as at sea level. People who make rapid ascents to high altitudes in balloons and airplanes are unacclimatized. Tissandier in a balloon ascent fainted at 26,500 feet, and on regaining consciousness found both his companions dead. Yet on the other hand the Duke of the Abruzzi at 24,583 feet, and Rubenson and Monrad Aas at 24,015 feet, were not only capable of living but doing work as well. They were acclimatized by living for some time at the reduced pressure. Another factor that favors the trained mountaineer is that a trained man needs much less oxygen during work than an untrained man. He is an engine working with the maximum economy.

"The effects of intense cold on the human system is to lower the vitality, and there is no doubt that the cold at altitudes above 20,000 feet, with a wind, becomes almost paralyzing. Longstaff, Meade, Rubenson, all suffered from it. Yet Henri Brocherel after three nights out, the third spent in a hole in the snow at 23,000 feet, was able and anxious to continue climbing. There is little doubt that with acclimatized climbers in first-rate training a greater height will be reached than 25,000 feet. But it only will be done under the most favorable conditions.

"Probably the greatest difficulty will be getting the camps up to the high altitudes. The record at present is that of Mr. Meade's coolies, 23,600 feet on Kamet. Given another 1,700 feet and a camp 4,000 feet from the summit of Mt. Everest could be made. If the climbers in this camp were properly warmed and properly fed a push for the summit might be made. Dr. Longstaff 'rushed' Trisul, climbing almost 6,000 feet from his camp, and several other climbers have ascended many thousand feet in one day at very high altitudes. We more or less know that the physical difficulties on the summit of Mt. Everest are not prohibitive, and there is every reason to hope that the physiological ones will also not be great enough to stop a really determined attempt made on the mountain under favorable conditions."



MAP OF THE REGION OF MT. EVEREST

The dotted line shows the route which the expedition is taking

Mr. Abraham thinks that airplanes will not be used by the expedition at the outset. In fact, it is more than doubtful whether they will be of any real use at all. Control for landing purposes is impossible in the thin upper air, and as oxygen cylinders have to be used to sustain the pressure-stricken airmen, on account of the sudden uprush, it is evident that observation, a difficult undertaking among mountains, will be unreliable.

THE PLANS OF THE EXPEDITION

Two of the members of the expedition have written interestingly of their plans in the *Geographical Journal.* Col. Howard Bury, chief of the expedition, writes as follows:

"Part of the expedition may have to live at great heights for a considerable time, and one has been experimenting with small details such as primus stoves to burn at over 20,000 feet. You cannot keep fit unless you have good and hot food. It is of the very greatest importance to have food easily digestible, which can be easily warmed up at very great heights. The expedition has been organized by Sir Francis Younghusband, and to him has been practically due the fact that it has been brought into being. His energy here and his work with the various authorities have brought the expedition into being. The main object of the expedition is the ascent of Everest. But besides that, as Prof. Norman Collie has said, there are some very important subsidiary objects to be attained. The whole country to the north of Everest is completely unknown. The maps we have are all very problematical, and where you see a range of mountains marked in the map you may find it is a valley or lake, and as we go along we shall have to map our way. The Government of India has very kindly given us the loan of two officers of the Survey of India, both accustomed to mountain survey, and with them we shall have to work and map the whole of that country to the north of Everest, as well as the Mount Everest group; this alone would furnish a full summer's work. With these officers will be assistant surveyors, and a great deal of work has to be done. The Arun Valley is probably quite wrongly mapped, and we are very doubtful as to the exact position of those ranges of mountains marked to the north of Everest. The draughtsman who compiled the map told me they were put in to fill up!

"Now, Mount Everest is becoming known, like many other places at one time unfamiliar, as the island of 'Yap' came into prominence a few months ago. I heard two ladies discussing the expedition recently, and at last one said to the other, 'And where is Mount Everest?' 'Oh, somewhere in Iceland!' Another remarked to me, 'Oh, how very interesting your going to Everest! I hope you may get to the top, and then you may bring back a piece of wood from the Ark!'

"We have a good botanist and naturalist, and there is every probability of our discovering many new flowers; but that very much depends on how far the monsoon currents penetrate up the Arun Valley. It is extraordinary on those dry plains, which look so barren in the photographs, what beautiful flowers there are—most lovely rock plants, blue poppies, primulas, and all kinds of delightful flowers. There is also the geological work. We are probably getting either an officer or assistants from the Government of India for making a geological collection. We know there are a large number of animals up there. You get Ovis Ammon, one of the largest sheep in the world; possibly an antelope, certainly a gazelle, and partridges, and there is a great field for a naturalist.

"The Government of India is kindly giving us the loan of 100 mules for the expedition. This will be of the very greatest assistance to us, and we know now we shall have no difficulties with the transport. Lord Ronaldshay, the Governor of Bengal, is extremely interested in the expedition, and we are lucky in having him there. Colonel O'Connor is political agent in Sikkim, and his duties carry him right up into Tibet. He was with Sir Francis Younghusband in the expedition of 1904.

"It is, therefore, a specially favorable time for us to make this expedition with so many friends who will be quite ready to help us. There is a very elaborate photographic equipment going out with the expedition, so that we hope to bring back many records. Unfortunately the camera cannot reproduce the extraordinary beauties of color there are in Tibet—greens, and reds, and orange, under a brilliant blue clear sky. It is a wonderful expedition, full of interest of all

kinds, and when we come back I hope we shall have a very interesting tale to tell you."

THE MOUNTAINEERING

Mr. Harold Raeburn, leader of the mountain party, writes as follows:

"Seeing that the political difficulties in connection with this expedition have been so happily overcome, we shall hope that difficulties of approach, that Prof. Norman Collie has described as very great, will also be successfully overcome owing to the careful organization of the transport, which is really the secret of getting a large party up there. There remain the mountaineering difficulties, and these will undoubtedly be extremely great. No one has ever seen the real approaches to Everest because its lower slopes have been always concealed by the shoulders and slopes of its mighty neighbors. I do not think the northern ridge will prove at all possible, because I do not think anybody can live at such enormous elevations for such a long time as would be necessary. I was privileged last year, by very kind permission of the authorities of India and Nepal, to make a reconnaissance of Kangchenjunga, and I think in studying passages and probable conditions, we can, to a large extent, depend upon analogy. Great snow mountains are great snow mountains all the world over. These two great constellations of peaks, Everest and Kangchenjunga, at no great distance apart, are separated by an enormous river valley, the Arun, but probably conditions are very much the same. I think it very unfortunate indeed that for political reasons alone we are precluded from taking the easiest route from the south. We must find some sheltered face route, and I believe that the northeast will be the most favorable for this reason, that the northwest is probably much steeper, and it has the cold aspect. Now altitude and cold are the two great things we have to struggle against. If we can get on the northeastern side we shall be much more likely to have sun early in the morning. As regards the actual mountaineering, everything will depend upon the training of the coolies, for I do not believe that Europeans can carry at these heights. Above 21,000 feet one has to have really well-trained and young, active men, and support them in every way. We may take it that this year will be reconnaissance first of all, but there is no doubt we shall try to get as high as we can, for Italians and Norwegians are ahead of us at present in altitude records. We intend anyway to do our very utmost to explore this great mountain so far as may be possible, and to justify Sir Francis Younghusband's keen interest and able generalship which has rendered it possible."

THE HIGH CLIMBING

Mr. (or rather Captain) George Finch, whom we saw repairing his boots in the June issue of the Scientific American Monthly, writes as follows:

"Those of us who have been selected by Sir Francis Younghusband to make, under the leadership of Mr. Raeburn, the attempt to climb the highest mountain in the world, do not conceal from ourselves the fact that we may expect to face great difficulties and dangers. I have heard a comparison drawn between this expedition and Polar expeditions. Such a comparison I have not found easy to draw. The Polar expedition is a long drawn-out struggle of several months. On this expedition remarkable difficulties are not likely to be met with below 20,000 feet. The ascent, however, of the remaining 9,000 feet to the summit of Everest will, if at all, be carried out in ten days or even less, and it seems to me those days will be replete with concentrated effort and strain such as no other expedition has ever demanded. I do not fear our inability to piece out an ultimate route up the mountain. By possible route I mean a route which is not only climbable, but where we are more or less safe from the danger of snow, ice or rocks falling upon us. The risk of our falling ourselves I hope may be eliminated. The question is whether the conditions will allow us to follow the route selected to the summit. On a mountain of such an enormous scale we shall be able to avoid difficult rock climbing. But I think every one of us will have to call up all he ever knew about snow conditions. These, to my mind, will prove one of our main difficulties. I do not mean we need fear avalanches coming down on us, for no good mountaineer recklessly ventures in their path. The great danger will be that at altitudes such as we hope to reach, we may meet with conditions of snow such as none of us has ever seen, of such a dry and powdery nature that all our previous experience of the angle at which snow may be ascended, still less crossed diagonally, may go for nothing. As to the question of altitude, Mr. Meade actually camped at 23,600. Dr. Kellas and Captain Morshead reached the same place last year without feeling any inconvenience. Indeed, Captain Morshead goes so far as to say he could have gone several thousand feet higher.

"I earnestly hope it may be my good fortune to be one of Captain Morshead's companions in overcoming the 6,000 feet still to be made. Dr. Kellas has recently carried out a valuable series of temperature observations at altitudes varying from 15,000 to 22,000 feet. By a process of extrapolation one can calculate from these data that temperatures of 60° fahr. are quite likely, indeed highly probable, on the summit of Mount Everest. In other words, the cold on this expedition will in all probability be arctic in its intensity. That in itself may not at first be considered a very serious matter, but it must be borne in mind that at high altitudes which must be attained the rate of evaporation of moisture and the loss of heat from the human body will be far greater than at sea level.

"One other question, and one which, as far as I am aware, was first recognized by Mr. Meade, is of great importance, and that is the effect of the exposure of the body to ultraviolet light. At high altitudes there are large quantities of ultraviolet light not kept back by the atmosphere. At low sea level we are protected. Ultraviolet rays impinging on the skin literally burn it, and the burning is followed by a feverish condition which hardly seems to me to be conducive to health and well-being."

Other writers in the same journal deal with the question of supplies, scientific investigations, photography, etc., but the exigencies of space forbid a fuller account of this highly scientific and eminently sportsman-like expedition. Meantime Mt. Everest, cold and calm in the heart of Asia, awaits the slow but sure footfalls of the Anglo-Saxons. May their efforts help to round out the achievement of Admiral Peary and establish the pre-eminence of English speaking explorers, and may they all return safely from this most perilous enterprise.

CRYOGENIC LABORATORY OF THE BUREAU OF MINES

On the twenty-first of May the new Cryogenic Laboratory of the Bureau of Mines was opened, the equipment having been supplied from funds allotted to the Bureau from the Navy, the Army Air Service, and the Bureau of Mines. The object of the laboratory is to obtain scientific data that will be of use in the operation of the helium plants, an effort to obtain more efficient operation and to reduce further the cost of helium.

A second object is to furnish facilities to scientists who are interested in very low temperature work, particularly along the lines not covered in the Bureau's present program.

At present vapor pressure work in connection with the ternary mixtures and the purification of helium with charcoal at low temperatures constitute a part of the work. It has already been found that charcoal has a selective absorption at low temperatures removing nitrogen but not absorbing helium. This property has been utilized in purifying helium both from nitrogen and from the air.

The importance of purity is unusually great as the difference between 100 per cent helium and 94 per cent is very great when expressed in lifting power and range of operations for a helium-filled balloon. The Army has constructed a repurification plant on railroad cars and the Bureau of Mines will install a charcoal unit testing out the entire device before it is installed on the car.

Courtesy of the Metropolitan Museum of Art

A GROUP OF GREEK VASES OF THE FIFTH AND SIXTH CENTURIES B.C. AT THE METROPOLITAN MUSEUM OF ART. THE ATHENIAN PYXIS, AT THE RIGHT DATES BETWEEN 470 AND 460 B.C. IT DEPICTS THE JUDGMENT OF PARIS

Dynamic Symmetry

The Rediscovery of the Basic Principles of Greek Art

NOT only the artist and the architect but the structural engineer and the devotee of pure science will find it of the greatest interest to follow the steps by which the well-known draftsman and illustrator, Mr. J. Hambidge, of New York has been led to formulate the remarkable theory of "dynamic symmetry," in which he believes he has rediscovered those principles which guided the artists of Greece's greatest period in the making of their imperishable works whether of sculpture, of architecture, or of pottery. These basic principles are, however, by no means artificial. On the contrary, they are those which underlie the proportion not only of the human frame, but of the growing plant.

Mr. Hambidge, who has been studying the subject with glowing enthusiasm for many years, has recently been in Europe gathering fresh data to support his views from the surviving masterpieces of classic art in old-world museums. Previous to sailing he devoted two years to the giving of a series of lectures at Yale and at Harvard and to special classes of artists, sculptors, designers and teachers in New York and in Boston. It is his purpose to publish a series of books dealing with the various phases of the subject. The first of these, which is entitled "Dynamic Symmetry," was recently published by the Yale University Press, which is also sponsor for the illustrated monthly magazine called *The Diagonal*, whose object is stated in its subtitle "An Illustrated Monthly Magazine devoted to the Explanation of the Rediscovered Principles of Greek Design, Their Appearance and Nature and Their Application to the Needs of Modern Art."

The first volume mentioned above deals entirely with Greek vases but it is the author's intention in the subsequent volume to deal with other phases of classic art, such as bronzes and marbles, decoration and architecture.

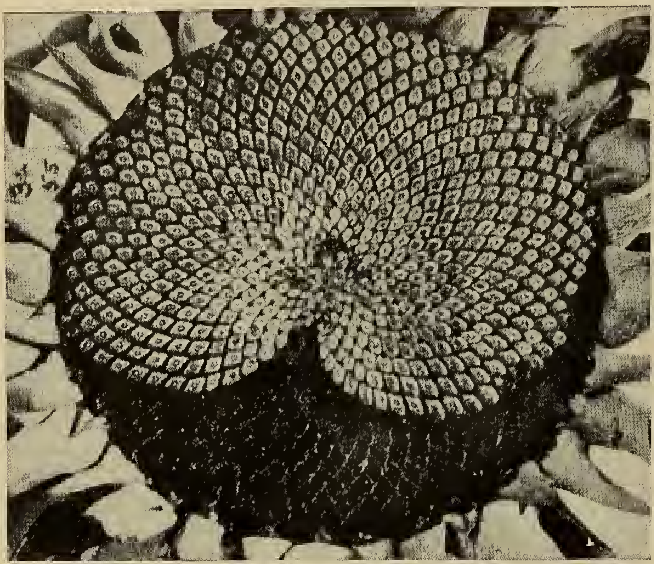
The study of the impersonal aspect of art in relation to the symmetry of natural form, was begun some twenty years ago, and it was found that there are only two types of symmetry found in nature capable of being employed in design. One of these types is termed "static" and the other "dynamic." The former is, of course, the simplest, thus the savage decorating his canoe, his blanket, or his earthen jug, uses static symmetry unconsciously, but it is impossible, says Mr. Hambidge, to make use of dynamic symmetry unconsciously. He finds that there were only two peoples, indeed, who made use of dynamic symmetry at all—the Egyptians and the Greeks. The former developed it possibly as early as the first or second dynasty, from an empirical or "rule of thumb" method of surveying. Some slight knowledge, too, of this form of symmetry was shown to the Hindus about the 5th or 8th centuries, B.C. The Greeks learned its principles from the Egyptians some time during the 6th century B.C. and they supplanted, probably quite rapidly, a sophisticated type of static symmetry then in general use among them. These master minds of the ancient world, however, soon developed the theory and practice of dynamic symmetry far beyond their masters and made the discovery, within a few years, that this symmetry is essentially identical with the symmetry of growth in the human being. Vitruvius, to whom we are indebted for such knowledge of the Greek principles of art, as has come down to us, declared that the Greeks *learned* symmetry from the human figure and applied it to their works of art, especially their temples. It is now believed, however, that Vitruvius was mistaken in this as in various other statements. The Roman architect had no knowledge of symmetry beyond a crude form of static symmetry. He declared, accordingly, that the Greeks used a modulus, *i.e.*, a definite unit of length, to determine the symmetry of their temples and gives elaborate instructions as to how the plans were developed. But Mr. Hambidge declares that no Greek design has been found which agrees with the statement of Vitruvius and he adds that the modulus could only produce a grade of static symmetry which a Greek would have found so crude as to be amusing.

Stated in brief *the essential principle of dynamic symmetry is that multiples of areas instead of multiples of linear units are involved.* In other words the architecture of a man or a plant must be studied from a *projection*, *i.e.*, from a two-dimension drawing; this projection always represents some arrangement of two-dimension form within a rectangle and these rectangles both individually and as a group possess marvelous properties of proportional subdivision.

An excellent idea of dynamic symmetry as found in a plant can be obtained by a study of the arrangement of the seed in the head of a sunflower.

THE PHENOMENON OF PHYLLOTAXIS

It has long been known that a special series of numbers is connected with the phenomenon of the regular arrangement found in the leaves of plants. This series is called a summation series from the fact that each term is composed of the sum of the two preceding terms, as follows: 1, 2, 3, 5, 8, 13, 21, 34, 55, etc. This subject is discussed in great detail in the well-known works by Prof. A. H. Church of Oxford, entitled "Phyllotaxis in Relation to Mechanical Law." This series of numbers in reality represents the symmetry of the plant in the sense that the word is used as "analogy," which is its Greek meaning. From this series we obtain the entire machinery of dynamic symmetry, which applies not only to the architecture of the plant but to the architecture of man.



SUNFLOWER HEAD SHOWING THE CURVES FOLLOWED BY THE SEEDS

This summation series of numbers, because of its character, represents a ratio, *i.e.*, it is a geometrical progression. This ratio may be obtained by dividing one term into another, such as 34 into 55. The series does not represent the phenomenon exactly but only so far as it is representable by whole numbers. A much closer representation would be obtained by a substitute series such as: 118, 191, 309, 500, 809, 1,309, 2,118, 3,427, 5,545, 8,972, 14,517, etc. One term of this series divided into the other equals 1.6180, which is the ratio necessary to explain the symmetry of the plant design system.

The operation of the law of leaf distribution and its connection with the summation series of numbers is explained by Professor Church, who uses as illustration the disk of the sunflower.

"The most perfect examples of phyllotaxis easily obtainable are afforded by the common sunflower, so frequently selected as a typical Angiosperm, both in anatomical and physiological observations, owing to the fact that it exhibits, par excellence, what is regarded as a normal structure little modified by specialization for any peculiar environment. Not only is the sunflower a leading type of the Compositæ which holds the highest position among Angiosperm families, but among this family it flourishes in the best stations, in which sunlight, air, and water supply are perhaps at an optimum for modern vegetation. The very fact that it is as near an approximation to the typical Angiosperm as can perhaps be obtained, suggests that the phenomena of growth exhibited by it will also be normal, and from the time of Braun to that of Schwendener it has afforded a classical example of spiral phyllotaxis."

The sunflower heads may be readily observed. By taking a head in which the last flowers are withering, and clearing away the corolla tubes "the developing ovaries are seen to mark out rhomboidal facets, and when the fruits are ripened, and have been shed, the subtending bracts still form rhomboidal sockets. These sockets, with or without fruits, form a series of interesting curves identical with those of the pine cone, only reduced to a horizontal plane.

"A fairly large head, 5 to 6 inches in diameter in the fruiting condition, will show exactly 55 long curves crossing 89 shorter ones. A head slightly smaller, 3 to 5 inches across the disk, exactly 34 long and 55 short; very large 11-inch heads give 89 long and 144 short; the smallest tertiary heads reduce to 21 to 34 and ultimately 13 to 21 may be found, but these, being developed late in the season, are frequently distorted and do not set fruit well.

"A record head grown at Oxford in 1899 measured 22 inches in diameter, and, though it was not counted, there is every reason to believe that its curves belonged to a still higher series, 144 to 233. The sunflower is thus limited in its inflorescence to certain set patterns, according to the strength of the inflorescence axis, *e.g.*, 13/21, 21/34, 34/55, 89/144. These were first observed by Braun (1835), and translated into terms of the Schimper-Braun series they would correspond to divergencies of 13/34, 21/55, 34/89, 55/144, and 89/233, respectively. Under normal circumstances of growth, the ratio of the curve is practically constant. (Cf. Weisse. Out of 140 plants 6 only were anomalous, the error being thus only 4 per cent.)"

The ratio 1.6180, when reduced to a rectangular area makes a rectangle which has been given the name by Mr. Hambidge of the "rectangle of the whirling squares."

METHODS OF MANIPULATING THE PLANT FORMS OF NATURE

Mr. Hambidge's idea is that the most distinctive shape which we derive from the architecture of the plant and the human figure is a rectangle which has been given the name "root-five." It is so called because the relationship between the end and side is as one to the square root of five, 1:2.2360 plus. As a length unit the end cannot be divided into the side of a root-five rectangle, because the square root of five is

DYNAMIC SYMMETRY AS APPLIED EVEN TO AN ANCIENT GREEK FRYING PAN

a never-ending fraction. We naturally think of such a relationship as irrational. The Greeks, however, said that such lines were not irrational because they were commensurable or measurable in square. This, according to Mr. Hambidge, is really the great secret of Greek design. In understanding this measurableness of area instead of line the Greek artists had command of an infinity of beautiful shapes which modern artists are unable to use. The relationship between the end and side of a root-five rectangle is a relationship of area and not line, because as lengths one cannot be divided into the

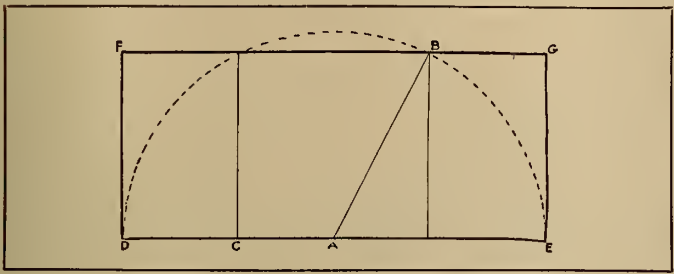


FIG. 1

other, but the square constructed on the end of a root-five rectangle is exactly one-fifth of the area of the square constructed on the side. The areas of rectangle which have this measurable relationship between end and side possess a natural property which enables us to divide them into smaller shapes which are also measurable parts of the whole.

THE ROOT RECTANGLE AND THE RECTANGLE OF THE WHIRLING SQUARES

The construction of a root-five rectangle is simple. Draw a square as BC in the diagram (Fig. 1) and bisect one side as at A. Draw a line from A to B and use this line as a radius to describe the semicircle DBE. AE and AD are equal to AB, or the line DE is twice the length of the line AB. Complete the rectangle by drawing the lines DF, EG. It will be noticed that the rectangle FE is composed of the square CB and two rectangles FC and BE. This is the *root-five* rectangle and its end to side relationship is as one to the square root of five, 1:2.2360: the number 2.236 being the square root of five. Multiplied by itself this number equals 5.

In Mr. Hambidge's theory this root-five rectangle is the basic shape of vegetable and animal architecture and is the form which has solved the mystery of the perfection of classical Greek art.

THE RECTANGLE OF THE WHIRLING SQUARES

The root-five rectangle produces a great number of other shapes which are measurable in area with themselves and with the parent shape. The principal one of these is that which is called by Mr. Hambidge *the rectangle of the whirling*

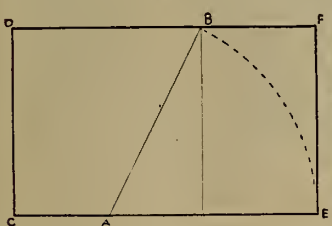


FIG. 2

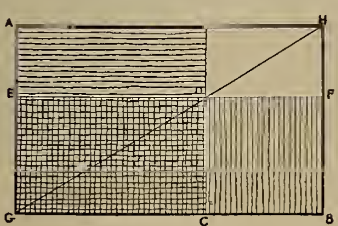


FIG. 3

squares. The relationship of this rectangle to the root-five rectangle is shown by its construction. Draw a square as CB in Fig. 2. Bisect one side as at A. Draw the line AB and make AE equal to AB. Complete the rectangle by drawing the lines BF, FE. This rectangle, DE, is the rectangle of the whirling squares. It is composed of the square CB and the rectangle BE. It is apparent that this shape is equal to the root-five rectangle minus one of the small rectangles FC or BE of Fig. 1.

As has been said above, the construction of the shapes of vegetable and animal architecture is simple and if we wished to begin using them in design little more would be necessary. Unfortunately we cannot afford to wait to discover all the wonderful properties possessed by these simple shapes by practically employing them in our design problems. Time is too short and our needs too great. But, fortunately, as Mr. Hambidge points out, we have the use of a tool which the Greek artists did not possess. That implement is arithmetic. "By the use of a little adding, multiplying, dividing and subtracting, we may expedite our progress enormously. This will be apparent if we consider the square of the root-five rectangle as representing one or unity; this may be 1. or 10. or 100. or 1000, but it will always be a square as an area of sides of equal length. Regarded thus it will be apparent that the area of any rectangle may be composed of one or more squares plus some fractional part of a square. The square root of five is 2.236; if one is subtracted from this number the result will be 1.236. In this case 1.236 represents the two small rectangles on either side of the square. If this number is divided by two, the result is .618. This number represents each one of the two small rectangles. We now see that the area of the root-five shape may be considered as 1 plus .618 multiplied by 2. Also it is now apparent that the area of the rectangle of the whirling squares may be considered numerically as 1 plus .618."

For the purpose of dividing up the areas of rectangles so that

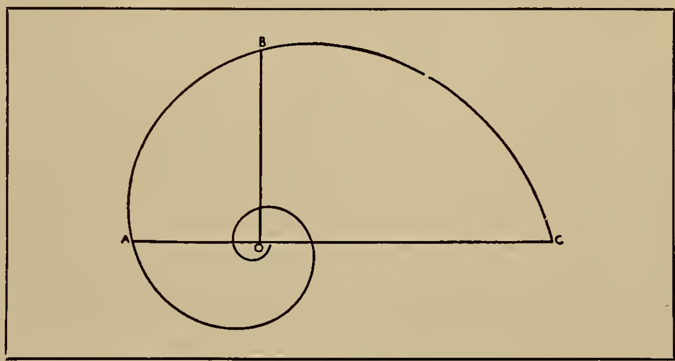


FIG. 4

the divisions would be recognizable, the Greeks had recourse to a simple but ingenious method which is called the "application of areas." (Fig. 3.) The idea was used by them both in science and in art. For a description of the process as used in science see any standard work on the history of Greek geometry. Classic design furnishes abundant examples of its use in art. The process in design may be illustrated by either of the rectangles described above. If to a rectangle of the whirling squares we apply a square on the end of that shape, the operation is equivalent to subtracting 1. from 1.618. A square on the end applied to the area of a whirling square rectangle leaves as a remainder a .618 area. If a square on the end of a rectangle is applied to its side, however, the operation is not so simple unless we use the Greek method. This process is shown in diagram Fig 3.

"To the rectangle AB the square on the end AC is applied. To apply this same square to a side as BC we must first draw a diagonal to the whole shape as GH. This diagonal cuts the side of the square AC at D. Through the point D we draw the line EF. The area EB is equal to the area of the square AC. This process applies to any rectangular area whatever which may be applied to either the end or the side of a rectangle. It will be noticed that the square on the end of a rectangle when applied to a side changes its shape, *i.e.*, it is no longer a square, though equal in area to the area of a specific square. It is clear that now it is composed of a square plus some other area which may be composed of either a square or squares or some fractional part of a square. In the rectangles which we find in plant and animal architecture

and in Greek art this area of a square applied to a side of such shapes is always understandable or measurable in terms of the whole."

HOW DYNAMIC SYMMETRY WAS DISCOVERED

To the end that the artist may understand the essential idea connected with the form rhythms observable in plant architecture and apply it to his immediate needs, it is advisable to digress at this point and explain how observation of this from rhythm led to the discovery of Dynamic Symmetry. Many years ago Mr. Hambidge became convinced that the spiral curve found in *plants* which Professor Church describes in his work on the law of leaf distribution, and that of the curve found in spiral shells were identical and must be the equiangular or logarithmic spiral curve familiar in mathematics. In this connection the reader is referred to a paper by the Rev. H. Moseley "On the Geometrical Forms of Turbinated and Discoid Shells" (Phil. Trans., pp. 351-370, 1838), and to the lucid treatment of the spiral by D'Arcy W. Thompson. ("Growth and Form," Cambridge, Eng., 1917.) Being convinced that the spiral was indeed the mathematical curve mentioned Mr. Hambidge saw that, because of a certain property which it possessed, this spiral could be reduced from a curve to one composed of straight lines and thereby be used by the artist to solve certain problems of composition and connect design closely with nature. This property of the curve is expressed as follows: Between any three radii vectores of the curve, equal angular distance apart, the middle one is a mean proportional between the other two. The drawing,

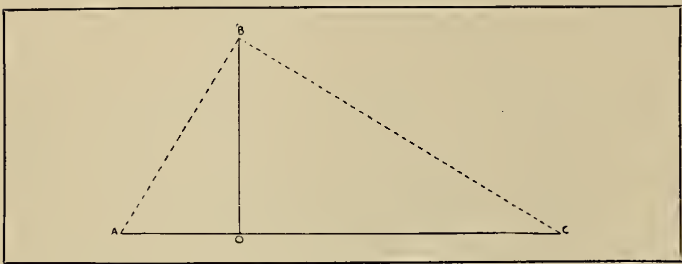


FIG. 5

Fig. 4, explains this. O is the pole or eye of the curve and the lines OA, OB, OC are radii vectores equal angular distance apart. In this case the angle is a right angle. According to the definition the line OB is a mean proportional between the other two, *i.e.*, OA and OC. This means, speaking in terms of area, that the line OB is the side of a square equal in area to a rectangle the end and side of which are the lines OA and OC. It necessarily follows, therefore, that if three lines stand in this relationship they constitute the essentials of a right angle. This is shown in Fig. 5. The line OB is a mean proportional between the lines OA and OC and the shape ABC is a triangle, right-angled at B, and the line AC is the hypotenuse. One of the earlier geometrical facts determined by the ancient Greeks was that in a right-angled triangle a line drawn from the intersection of the two sides to meet the hypotenuse at right angles was a mean proportional between the segments of the hypotenuse. Simply stated, this means that three lines situated like the three radii vectores mentioned constitute three terms of a continued proportion; OA is to OB as OB is to OC. The relation between these lines could be stated arithmetically as a ratio, this following from the fact that lines in continued proportion form a geometrical progression. If we assume, for example, that the ratio is 2 and the length of the line OA is two units then the line OB would be four units and the line OC eight units. 2, 4 and 8 constitute three terms of a simple proportion with a ratio of 2 and according to the rule of three, the square of the mean is equal to the product of the extremes. In this case 4 is the mean and 2 and 8 are the extremes. 4 multiplied by itself, or squared, equals 2 multiplied by 8. The mean is the side of a square equal in area to the area of a rectangle made by the extremes or 2 as end and 8 as side. But the line OB (Fig. 6) may be produced through the pole O of the spiral until it touches the curve at the point D and DAB will be a right angle and there will exist four lines in continued proportion, OD, OA, OB and OC. Also the curve cuts the vector lines at E and F, etc., and other right angles are created. In short, the curve may be reduced from a curve to a rectangular spiral (Fig. 7) and, as in the curve, the converging right angles wrap themselves to infinity around the pole. This particular curve never reaches the pole, it goes on forever.

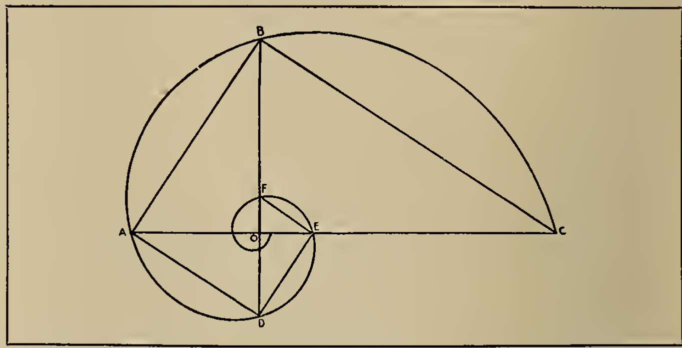


FIG. 6

The essential point is that this simple construction enables the designer to introduce the law of proportion into any type of composition and that, too, in much the same way as it appears in the plant and the shell. The operation by which this is accomplished is the drawing of a diagonal to a rectangle and a line from one corner cutting this diagonal at right angles (Fig. 8) is any rectangle and AB is a diagonal. The line CD, drawn from the corner C, cuts the diagonal AB at right angles at O. It is apparent that the angular spiral formed by the lines AC, CB, BD, DE and EF is identical with the angular spiral derived from the shell and from the plant. Having established a condition of proportion within the area of a rectangle it becomes obvious that the line CD must perform some important function. Artists are well acquainted with at least one property of the diagonal to a rectangle. It is well known, for example, that any shape drawn within the area of a rectangle whose diagonal is common to the diagonal of the containing area is a similar shape to the whole. This geometrical fact is utilized in the arts, especially the reproductive arts, for the purpose of determining similar shapes on a larger or smaller scale. This, however, is about as far as modern artistic knowledge of proportion

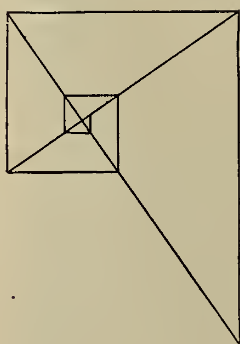


FIG. 7

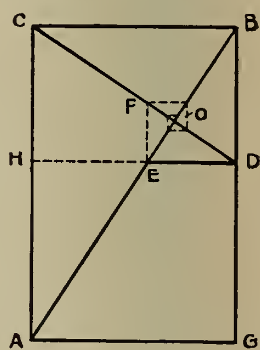


FIG. 8

extends. The value of the line CD is unknown to modern art. That the value of this was known at one time in the history of art and its power appreciated is abundantly proven by dynamic analysis of classical Greek design. This line CD determines the reciprocal of a rectangular shape and is itself the diagonal of that shape. Following the construction we appreciate the fact that, in a rectangular area, the diagonal of a reciprocal cuts the diagonal of the whole at right angles. The line DH (Fig. 8), which is drawn parallel to the ends

AG or CB, fixes the area of the reciprocal of the shape AB. With this notion of a reciprocal in mind it is apparent that the fatter or squatter the rectangle the larger will be the area of the reciprocal. For example, if instead of the rectangle AB of Fig. 8, one is constructed which much more closely approaches the shape of a square, the area of the reciprocal, because it is a similar shape to the whole, will also much more closely approach the shape of a square. The breadth of the reciprocal increases with the breadth of the partner form until it coincides with it as a square; or it decreases until both become a straight line. Obviously, also, there must be rectangles such that the reciprocal is some even multiple of the parent form, such as 1/2, 1/3, 1/4, 1/5 and so on. Perception of this fact led Mr. Hambidge to discover the root rectangles. It was found that a rectangle whose reciprocal equaled one-half the whole was a root-two rectangle; 1/3 a root-three, 1/4 a root-four and 1/5 a root-five rectangle and so on. When the root-five rectangle was defined and its commensurable area examined it was found that this shape was connected in a curious manner with the phenomena of leaf distribution. As has been explained, the ratio produced by the summation series of numbers which so persistently appears in the rhythmic arrangements of leaves and seeds in vegetable growth is 1.6180. When a rectangle was made wherein the relationship between the end and side was the ratio 1.6180 it was found that the end of the reciprocal of this area equaled .618. The side of a root-five rectangle, arithmetically expressed, is 2.2360 or the square root of five. If the ratio 1.6180 is subtracted from 2.2360 the remainder is .6180. The area of a root-five rectangle, therefore, is equal to a 1.6180 rectangle plus its reciprocal. The 1.6180 rectangle, because the end of its reciprocal equals .618, is a rectangle such that its *continued* reciprocals cut off squares and these squares form a spiral around a pole of that rectangle. This pole, of course, is the point where the diagonal of a reciprocal and a diagonal of the whole cross each other. Because of this property this shape was given the name "the rectangle of the whirling squares."

Courtesy of the Metropolitan Museum of Art

A GREEK STAMINOS BELONGING TO THE FIRST HALF OF THE 5TH CENTURY B.C.

DYNAMIC SYMMETRY AND GREEK POTTERY

The museums both here and abroad are particularly rich in Greek vases, large numbers of which have been found in the archaeological excavations. Many of them, too, are admirably preserved and, for this reason, they are peculiarly well adapted to the exemplification of Mr. Hambidge's views. As stated above the first volume of his projected series is devoted entirely to a study of the Greek vase, and it contains over 200 carefully made analytical drawings of vases, most of which are included in the collections of the Metropolitan Museum of this city, the Boston Museum of Fine Arts, and the Yale Museum. They include the chief forms, the amphora, the kylix, the pyxis, the krater, the lekythos, and the lebes. Each of these delicate works of art forms a beautiful composition in which the various details repeat the primary theme, thus producing a unified harmony. In other words the rectangles made by the width and the height of the lip, the neck, the body, the foot, and the handles, respectively, bear a definite mathematical relation to the rectangle which contains the vase as a whole. In the words of Gisela M. A. Richter, of the staff of the Metropolitan Museum of New York City, "We have an interplay of areas comparable to the sequence of phrases in a musical composition." Miss Richter, by the way, calls attention to the fact that in spite of the exact mathematical dimensions involved the scheme is in no way a mechanical device, but merely a useful framework within which the artist's imagination has free play. She remarks, finally, "It no more impedes individuality than harmony obstructs the composer or a metric system the poet. It merely supplies that sense of law and order which we know to be one of the dominant characteristics of Greek art."

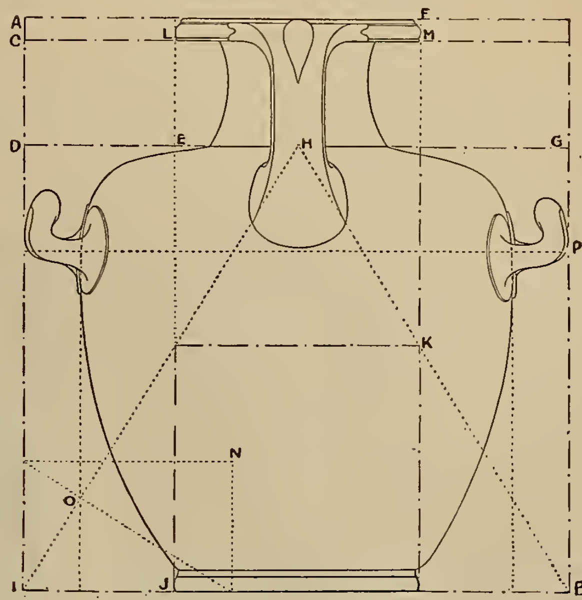


FIG. 9. A GREEK HYDRIA ANALYZED BY MR. HAMBIDGE

Our illustrations include some of the beautiful specimens in the Metrpolitan Museum copied and analyzed by Mr. Hambidge.

THE DYNAMIC SYMMETRY OF THE HUMAN FIGURE

The limits of this brief article forbid us naturally to give an extended account of Mr. Hambidge's minute and careful study of the applications of his theory to the human figure, but it is worth while attempting to give in brief the main features of his method of study. He begins by making the rather startling statement that human anatomy as now taught in art schools, is of little if any use to the artist. The only anatomy the artist requires to have a knowledge of is of a type which brings out the *larger pattern forms of the structure of the body.* He declares explicitly "surgical anatomy leads to an overstress of detail and a violent squirm and twist of the figure incompatible with noble design. The Greeks used the correct type of anatomy. But we must not study Greek anatomy by itself; we must study nature and use Greek knowledge to explain something of the subtlety of construction and the beauty of man's structure." He tells us further that the great span ratio or index for the average man

i.e., the distance between the tips of the middle fingers when the arms are fully extended is 1:1.045. This index is determined by dividing the height of the individual into the span and the average quoted was found by summarizing the measurements of thousands of persons. This average, of course, is often exceeded in well-built individuals. There is in the Museum of the Harvard Medical School a remarkable skeleton of a man who must have been nearly six feet tall when living. The great span of this skeleton makes with the full height a double root-five rectangle. This gives a span ratio of 1:1.108. But this ratio is the square root of 5 divided by 2; 2.236 divided by 2 equals 1.118. "This is the ratio of a rectangle which was used repeatedly by Greek artists, as is shown by some of the finest examples of design which have survived. The rectangle, which encloses the side elevation of the head, is also a double root-five rectangle. The rectangle which encloses the torso and head is a root-five rectangle. Moreover, the length of every bone in the example is expressible arithmetically in figures of the dynamic symmetry series if the measurements are made with a metric scale."

Mr. Hambidge makes use of the skull of this same skeleton as a subject of analysis and his method will be of interest especially to students of art. Before a skull or a head from a living model can be measured so as to establish a rhythmic area theme, it is necessary to draw a line across it, which will definitely fix it at right angles to the erect position of the figure. This line represents what anthropologists call a plane. Various authorities have employed no less than fifteen different skull planes but Mr. Hambidge has found the best one to be that drawn from the center of the opening of the ear to the upper ridge of the bottom bone of the eye socket. When this line has once been fixed the rectangle of either the front or side elevation is easily determined. The importance of this line is due to the irregular nature of the skull or the head. Without this line the skull may be fitted into many rectangles, according to the degree to which the chin is raised or lowered. But with this basic line once settled, there is only one rectangle for the side and one for the front elevation. In the author's words: "When we find that these two rectangles are logical elements in an encompassing rhythmic theme in commensurable area which takes in every detail of the human structure, we may feel confident that we are proceeding correctly."

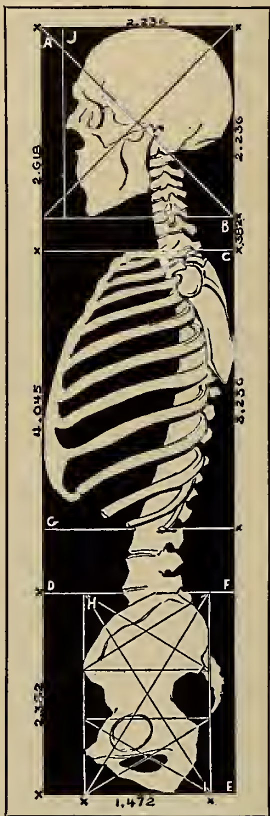


FIG. 10. ANALYSIS OF A SKELETON IN THE HARVARD MEDICAL SCHOOL

WONDERS OF THE ENAMELER'S ART

By J. H. Davies

From the days of the construction of the magnificent enameled brick walls of the palace of Rameses III., at Tel el-Yehudia, in the delta of the Nile, to our own time, the art of emaneling has engaged the efforts of workers in precious materials. And the art of decoration in enamel is as universal as it is ancient. Its history can be traced through the centuries and throughout the eastern and western worlds alike. It has left us such relics as the walls of the palace of Nimrod, in Babylon; the enameled gold and silver ornaments of Greece and Rome; the barbarously beautiful enameled horse trappings, weapons and jewelry of the ancient Celts and Saxons. Byzantium, Cologne and Limoges became famous centers of the art; and 14th century Italy raised it to previously unattained heights.

Until this time, and even further, to the end of the 15th century, all enameling had been of the cloisonné type, the "cloisons," or little metal-bounded compartments containing the enamel having been believed necessary to preserve the form of the designs and separate the colors. But now came the solid enameling of metal surfaces as well as various other developments. Translucent enamels, painted enamels, and enamels revealing engraved designs on the underlying metal were perfected. Very recently Mr. Alexander Fisher, well known for his exquisite enamels, has perfected the art of making a solid enameling from which the metal backing is then removed, producing a clear transparent subject in color. He has also been successful in producing a colored enamel relief resembling the Della Robbia relief, save that the color of the enamel by its nature permeates the whole depth of the relief, whereas in the Della Robbia ware it is only on the surface. It also has a fresco, or dull-finish, instead of a highly-glazed surface.

There has recently been a great commercial stimulus to the art of enameling. Just before the war this activity reached a point never before attained. Throughout Europe and in the United States and Japan the production was great. One o fthe phases of the unusual interest was a demand for imitations of old pieces, especially of old Chinese work. As Chinese cloisonné has always been deservedly admired, it is interesting to recall the process used in making it.

Ancient enameling was done on gold, silver and other precious metals. Today, however, the foundation most in use is red copper. The drawing of the intended decoration is first sketched on paper. In the Hall of the Living Tribes of Asia, in The American Museum of Natural History, in New York City, the entire cloisonné process is shown by means of pieces of work in successive stages and a printed explanation. The first step is the colored design on paper. Then the design is transferred to the vase to be decorated by tracing with a stylus. A net-work of thin flat copper wire, following the outlines of the tracing is fastened to the vase by means of a kind of glue prepared from root of orchid. For this purpose, resin is sometimes used. To hold the spirals of this wire-outlined design in place, tiny fragments of a very hard refractory substance are inserted between them at regular intervals. The whole is then powdered over with a compound made of silver filings, copper and borax. The vase is now enclosed in an iron vise or ferrule, placed in the middle of an iron-wire cage filled with charcoal. It is exposed to the fire for 15 minutes, a perfect soldering being thus achieved. The piece is then taken from the fire and washed in an acid decoction of apricots with a brush. It is now ready to receive the enamel.

Into the cell-like compartments, or "cloisons," as they are technically called, formed by the windings of the copper wire, the enamel paste is introduced by means of a tiny iron trowel, the colors of the paste used corresponding to the colors of the design. When this process is finished, the vase is again fired. This operation requires great experience in determining the proper hardening point of the pigments. One firing requires not more than 10 minutes but does not always suffice to produce an even enameling over a large piece. Bubbles may appear, which have to be removed with a nail and little hammer, and the depressions are again filled with the proper colors. The Museum exhibit shows vases after various firings of this kind. Sometimes eight firings are required, the number depending on the colors and shades of color the enameler is seeking to produce.

The last step consists of polishing with a steel file. To render the surface uniformly even, further polishing is done with sandstone and lime-tree charcoal, while the vase is revolved on a lathe. Nothing now remains but the gilding of the interior of the vase, which at present is done exclusively by the galvanoplastic method instead of in the old-fashioned way with mercury.

The Elastic Force of Muscles*

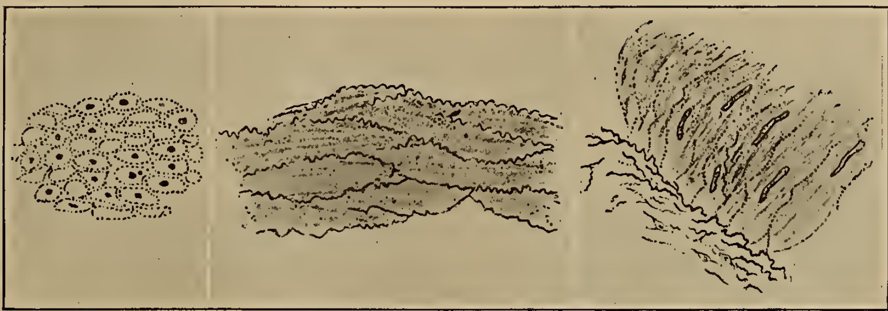
The Marvelous Artisans to Which We Owe All That the Hand of Man Has Accomplished

By Professor I. Athanasiu

Of the Faculty of Sciences of the University of Bucharest and Rector of the University

THE muscles of the body, especially those which possess striated fibers, are organs which have occasioned an immense number of investigations, some of which have concerned their structure while others, far more numerous, have dealt with their functions. There is nothing surprising in this when we recall the exceedingly important rôle which they are called upon to fulfil, not merely in the life of the individual but also in that of human society itself. To these marvelous artisans, indeed, we owe in the last analysis all that the hand of man has been able to accomplish.

In the following pages we propose to treat in a general fashion of the elastic force of the muscles. To this end we shall first examine the organ which develops this force and later, the part which it plays in the transformations of energy of which the muscles are the seat while engaged in fulfiling its proper function.



FIGS. 1 TO 3. ELASTIC FIBRILLAE SURROUNDING MUSCULAR FIBERS

1. Transverse section of smooth muscular fibers in the large intestine of a dog. The dotted lines represent the transverse section of the elastic fibrillae. 2. Longitudinal section of the smooth muscular fibers of a dog's bladder. 3. Oblique section of the smooth muscular fibers in the upper part of the stomach (cardia) of a horse

I.—THE ELASTIC ORGANS OF THE SMOOTH AND OF THE STRIATED MUSCLES

The majority of the studies made of the structure of smooth and of striated muscular fibers have had for their object their contractile substance, properly so called. But comparatively little work has been done with respect to the relations between this substance and the elastic and conjunctive tissues which surround it. Thus, the elastic fibers in the smooth muscles have been extensively studied by Treitz in 1863, Flemming in 1868, Baltzer in 1882, Drasch in 1894, Schaffer in 1899, Smirnow in 1899, Holmgrem in 1905, Mironesco in 1919, Trautmann in 1909, Lieto-Volaro in 1909, etc.; and the striated muscles have been studied by Martinaotti (1888) and Ranvier (1880 and 1890). This last histologist pursued the elastic fibers even up to their insertion upon a sarcolemma. Retterer and Lelièvre (1919) have gone still further and have described an elastic network or reticulum in the contractile substance itself of the striated fibers.

But the researches of these authorities have not succeeded in refining the intimate relations which exist between the muscular fibers, whether smooth or striated, and the elastic elements. This is readily explained when we recall the extreme delicacy of these elements at the point where they come in contact with the muscular fibers, which makes it impossible for them to be indicated by means of the various dyes employed in these researches. The case is analogous to that of the neurons whose delicate prolongations escaped the notice of histologists so long as they depended solely upon the usual dyes to render them visible. It did not become possible to observe them until the discovery of the impregnation by silver chromate (Golgi) and by reduced silver nitrate (Caj'al) which make the most minute nervous fibrillae absolutely black. In the same way the elastic fibrillae which are so refractory to most of the dyes employed in histology do not become visible until impregnation is employed.

In the researches made by me with the assistance of M. M. Dragoin and Ghinea upon the smooth muscles, and with that of the former upon striated muscles, we have employed Cajal's method, *i.e.*, impregnation by reduced silver nitrate, slightly modified.

II.—THE ELASTIC TISSUE OF SMOOTH MUSCLES

Each muscular fiber is surrounded by an envelop of elastic fibrillae, arranged parallel to its great axis, as can readily be seen in Figs. 1, 2 and 3. The first represents a transverse section of smooth muscular fibers, and the black dots which surround each fiber represent the transverse sections of the elastic fibrillae of the envelop. Fig. 2 shows the longitudinal section of the smooth muscular fibers between which we see the elastic fibrillae. Fig. 3 exhibits an oblique section of a smooth muscular bundle and we may observe how an *inter-fascicular* elastic fiber sends out very fine fibrillae which penetrate among the muscular fibers.

FIG. 4. ELASTIC TISSUE OF THE STRIATED MUSCLE

M, striated muscular fiber; *E*, perfibrillary elastic network

When we reconstitute, by means of these three sectional views, the smooth muscular fiber it appears to us as surrounded by a sheath formed of elastic fibrillae arranged lengthwise and exactly molding the body of the fiber. These elastic sheaths or envelops interlace with each other (anastomosis) to form a very closely woven *intra-fascicular* elastic system which is in direct continuation with the *inter-fascicular* system, as is the latter with the elastic system of the surroundning conjunctive tissue. All of the muscular and conjunctive elements of an organ having smooth fibers are enclosed therefore in a vast elastic network, and are continued without interruption in the thickness of the organ.

III.—THE ELASTIC TISSUE OF THE STRIATED MUSCLES

Impregnation by reduced silver nitrate shows in the first

*Translated for the *Scientific American Monthly* from the *Revue Generale des Sciences* (Paris), for June 15, 1920.

place that the sarcolemma is composed of three layers: an external layer of conjunctive nature, whose fibrillae are derived by the dissociation of the inter-fascicular conjunctive fibers (Fig. 4 M); a middle layer of elastic nature whose fibrillae interlace to form a network (Fig. 4 E); and an internal layer of homogeneous aspect which is in immediate contact with the contractile substance and which is formed by a mingling of elastic and conjunctive tissue.

But in these fibers we may go still further and see in the contractile substance itself grains which become impregnated

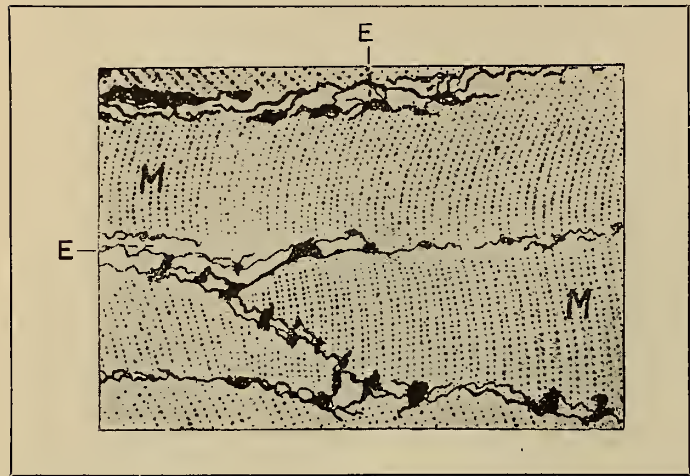


FIG. 5. GRAINS IN THE CONTRACTILE SUBSTANCE

M, striated muscular fiber showing the grains of the impregnated clear zones; *E*, elastic fiber and nodes of their anastomoses

like the elastic tissue. They occupy the light-colored bands in two rows on one side and the other of the stria of Amici (the thin disk) in Fig. 5. In the dark disk we see a single row of grains, much smaller, which are also impregnated by the reduced silver nitrate and which correspond to the membrane Z, or intermediate stria of Hensen (Fig. 6 H). Their impregnation coincides generally with that of the conjunctive tissue which impels us to believe that they contain more collagen than elastine. It separates the two rows of rods which compose the substance of the dark disks, as has been shown by Ranvier, the great master of modern histology, as well as by Retzius and Van Gehuchten later. Each of these rods, therefore, is attached at one end to the membrane Z (the intermediate stria of Hensen), and at the other end to an elastic grain, an arrangement shown in the diagram of Fig. 7.

IV.—EXPERIMENTAL PROOF THAT THE GRAINS SHOWN IN THE CLEAR BAND ARE ELASTIC

Ranvier was the first to recognize the fact of the elastic properties of the clear bands of the striated muscular fiber, basing his opinion on the one hand upon their enlargement in extended muscles, and on the other hand upon the fact that they are mono-refractive like elastic yellow tissue.

We have tried to discover whether the grains which enter into the constitution of the clear bands, and which exhibit the same affinity for the reduced silver nitrate as does the elastic tissue, partake of the property of the latter. To this end we made the following experiment: Three portions of the same striated muscle were subjected to the impregnation in three different states; the first in its natural length, the second extended, and the third contracted. In these three preparations the form of the grains is different. They are spherical in the first, which comes from the muscle in a state of repose (Fig. 5); they are elongated in the direction of the greatest diameter of the fiber in the second, which comes from the stretched muscle (Fig. 6); and they are elongated in the transverse direction of the muscular fiber in the third, which is taken from the muscle fixed in a contracted state (Fig. 8).

This experiment shows that the grains in the clear band undergo a change of form under the influence of the forces which act upon them; *i.e.*, the tension or contraction of the striated muscular fiber. Hence they are elastic.

V.—RÔLE OF THE ELASTIC ELEMENTS IN THE FUNCTIONING OF THE SMOOTH AND STRIATED MUSCULAR FIBERS

The researches mentioned above having enabled us to determine the arrangement of the elastic elements in the muscles we are justified in regarding these elements as antagonistic springs of the contractile substance of the muscular fibers. This is their fundamental rôle, as was perceived by Ranvier, Retterer, and Lelièvre. In the smooth muscle the sheath of each fiber is deformed during contraction, and the elastic energy thus stored up in this sheath serves to bring the muscular fiber back to its initial length as soon as the contraction is at an end.

The sarcolemma of the striated fibers must have the same function. But since their return to their initial position must be far more prompt and rapid than in the case of the smooth fibers they have corresponding need of a more powerful spring, which explains the penetration of the elastic elements into the contractile substance itself, forming the clear bands mentioned above. Thanks to these the rods of the dark disk, which assume a globular form during the contraction, as Ranvier has shown, are quickly brought back to their cylindrical form.

The following experiment enabled Ranvier to catch this change of form of the dark disks during the contraction: the *sartorius* muscle of a rabbit was strongly extended and then placed in a tetanic condition by means of a strong induction current. A solution of osmic acid was then injected at once into its mass. The muscle was thus fixed in a state of excitation, but without being shortened. In the preparations obtained from this muscle and sketched by Ranvier can be seen the rods of the dark globular disks, when the clear bands are greatly elongated. This experiment provided the basis of his theory with respect to muscular contraction, according to which the dark disks are the active elements of the striated fibers, since the contraction of these fibers is due to the former's change of form. In becoming spherical they exert a pull upon the clear bands, causing these to become longer.

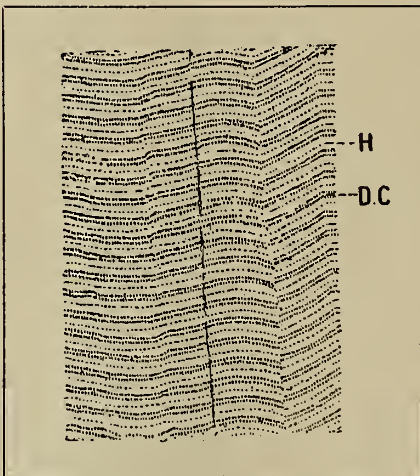


FIG. 6. STRIATED MUSCLE OF A RABBIT STRETCHED AND STIMULATED

DC, clear zone in which the grains are elongated in the direction of the diameter of the muscular fiber; *H*, intermediate stria of Hensen

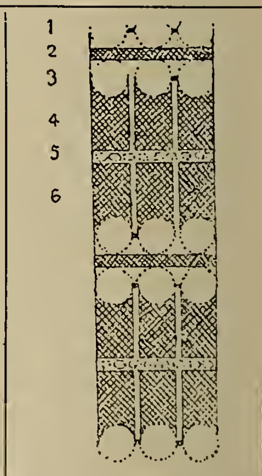


FIG. 7. DIAGRAM OF STRIATED MUSCLE

1, Clear semi-disk; 2, stria of Amici; 3, clear semi-disk; 4, dark semi-disk; 5, stria of Hensen; 6, dark semi-disk

But the theory thus formulated applies to the aforesaid case of the muscles which is excited but at the same time prevented from becoming shorter and this, of course, does not represent the normal method in which this organ functions. When fixed in the state of free contraction, *i.e.*, accompanied

with a decreasing length we observe, on the contrary, that the clear bands are diminished in height and are elongated in a transverse direction, as was proved by our experiment described above (Fig. 8). Hence all the elements of the striated muscular fiber becomes shorter during its contraction; consequently its mechanism is properly explained in the following manner: The rods of the dark disk which are cylindrical while in a state of repose tend to become spherical during contraction but without undergoing a change of volume; obviously, therefore, they compress the elastic grains of the clear band which is elongated in the transverse direction of the muscular fiber; this elongation is also assisted by the sarcolemma which pushed outward by the swelling of the dark disks exerts a pull upon the clear bands.

FIG. 8. TRANSVERSE SECTION OF STRIATED MUSCLE FIXED IN A CONTRACTED STATE

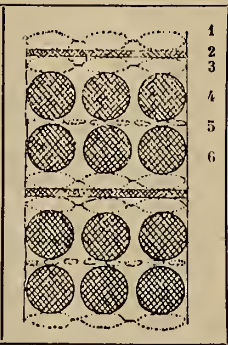


FIG. 9. CONTRACTED STRIATED MUSCLE—COMPARE WITH FIG. 7

The changes undergone during contraction by the dark disks and the clear bands are shown in Fig. 9. The elastic force stored up in the grains of the clear bands thus deformed serves to elongate the rods of the dark disk as soon as the contraction ceases.

There is no need, therefore, in order to explain the mechanism of contraction of the striated muscular fibers to assume either the expulsion of liquid matter by the dark disk as was believed by Krause and even by Ranvier as late as 1890 or, an absorption of liquid by this disk as was thought to be the case by Engelmann. This mechanism can be readily explained by the play of forces: the contractile force of the rods of the dark disk and the elastic force of the grains of the clear band.

VI.—THE ELASTIC FORCE OF THE SMOOTH AND THE STRIATED MUSCULAR FIBERS AND THE MECHANICAL WORK THEY PERFORM

The memorable experiments by Marey showed the utility of interposing an elastic spring between the motor and the weight to be displaced, for the potential energy stored up in this spring during its elongation would have been lost in the form of heat if the force of traction had been exerted without the intervention of the spring. Indeed this elastic energy not only greatly diminishes the shocks due to the inertia of the body, at the moment of its passage from the state of rest to that of motion, but by acting continuously upon this body it is converted into useful mechanical work done, and this augments the yield of the motor.

In the smooth muscles the elastic energy stored up in the sheath of each fiber is expended entirely to bring the latter to its initial length every time that its longitudinal diameter has been diminished with respect to its length in a state of repose (Fig. 10 *a* and *b*). But if the smooth muscular fibers happen to be distended by the contents of the viscera of which they form a part (Fig. 10*c*), then the elastic force of their sheath is added to that produced by the contractile surface in order to set in motion the aforesaid contents. It is converted therefore, into useful mechanical work done.

In the striated muscles the clear bands must diminish the shocks due to the passing of the contractile rod from the cylindrical form to the globular form. As for the conversion into mechanical work done of potential force stored up in the grain of these bands, this cannot be done by reason of the fact that this force acts during the elongation of the muscular fiber and not during its shortening which alone is capable of performing mechanical labor. It follows from this that the elastic force of the clear band is entirely expended to bring back the contractile rod of the dark disks to their initial length.

VII.—THE ELASTIC FORCE OF THE SMOOTH AND THE STRIATED MUSCULAR FIBERS AND THEIR COEFFICIENT OF ELASTICITY

It was long ago proved by physiologists that the elastic force of the striated muscle diminishes during its contraction, *i.e.*, that the same charge produces a greater elongation of the contracted muscle than of the muscle in a state of repose.

This diminution of the coefficient of muscular elasticity during a state of activity finds an explanation, in our opinion, in the potential energy which is stored up by the grains of the clear bands. This energy, in fact, which is due to their flattening (Fig. 8, contraction), is antagonistic to that developed by the contractile rods and in the same direction as the force which is seeking to lengthen the muscle. We can readily understand, therefore, that to produce an equal amount of elongation a lesser force of traction is required for the contracted muscle than for the muscle at rest, since the former is assisted by the elastic force of the clear band.

VIII.—ELASTIC FORCE AND MUSCULAR HEAT

The changes in the form of the elastic elements of the muscles must inevitably exert an influence upon the evolution of heat which takes place during their activity. It is well known in fact that the deformation of certain elastic bodies is accompanied by the absorption of heat. This is true of rubber which develops heat when stretched or compressed.

Elastic tissues behave in the same manner and we were convinced of this by experimenting upon the yellow cervical ligament of the ox. Thermo electric weldings (Constantan + iron) when placed in this ligament always exhibits a rise in temperature when the ligament is stretched and compressed, and the heat is proportional to the force exerted.

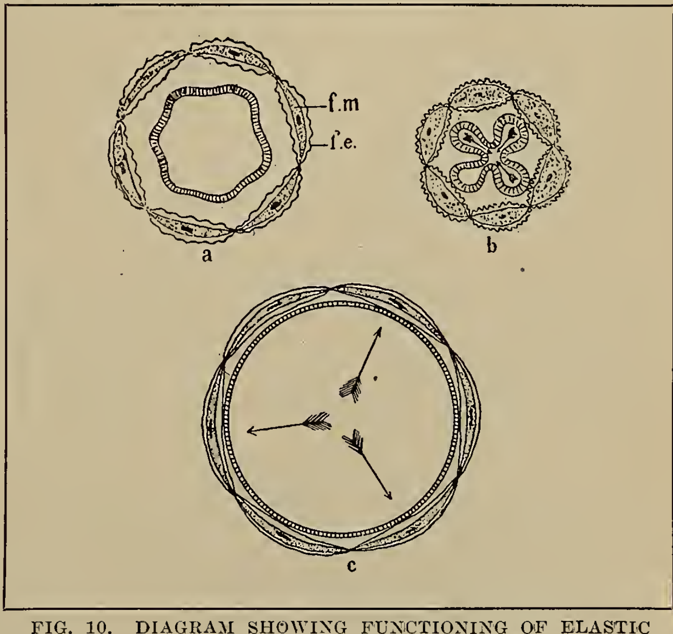


FIG. 10. DIAGRAM SHOWING FUNCTIONING OF ELASTIC AND CONTRACTILE FIBERS IN THE VISCERA

a, at rest; *b*, contracted; *c*, distended by contents of the viscera (*f.m.*, smooth muscular fiber; *f.e.*, elastic fiber of the envelope)

In our opinion we may explain by the fact thus discovered the phenomenon observed by Hill, namely that the heat produced during a muscular shock attained its maximum liberation before the end of the said shock. Probably part of this heat proceeds from the elastic grains of the clear band, which having absorbed the heat while becoming flattened liberates it during relaxation.

The Human Body as a Heat Machine

Studying the Vital Processes by Determining the Amount of Heat They Evolve

HUMAN calorimetry is the science whose object is to measure the amounts of heat liberated by the body under various circumstances and to determine the relation between these heat values and other factors involved in the vital processes, some of which inhere in the organism itself, such as age, weight, etc., while others are dependent upon external circumstances, such as the amount and nature of the food taken in.

It was the great Lavoisier himself who first attempted in 1780 to measure the amount of heat set free by a living organism. Making use of guinea pigs for his experiments he first proved that animals throw off carbon dioxide when exhaling and he then attempted to prove that the heat liberated by a given animal was equal to that produced by burning an amount of carbon equal to that contained in the carbon dioxide exhaled.

He began by measuring the carbon-dioxide (CO_2) produced by a guinea pig in ten hours. The amount of carbon contained in this amount of the gas should be capable when burned of melting 326 gr. of ice. In his second experiment, which likewise continued for ten hours he enclosed the same guinea pig in a sort of box surrounded by ice. He thus obtained 341 gr. of water proceeding from the melting of the ice by the warmth of the animal's body. These figures appeared to the great scientist to be sufficiently close to confirm his hypothesis allowing for unavoidable error. As a matter of fact, however, the results were only partially exact and that they should have approximated each other even thus closely was due merely to a happy chance: Lavoisier performed his calculations upon the theory that the exhaled carbon-dioxide was produced from carbon in the free state as when coal is burned. But as we now know the carbon in the body is found in highly complex combinations, such as glycogen, various albumenoids, etc.; it is necessary, therefore, to consider the heat which goes to form the carbon-dioxide from the point of view of these complex molecules and not from that of free carbon.

A very simple example will make this quite plain: when carbon-dioxide is formed by the combustion of free carbon 94 calories of heat are produced according to the equation

$$C + O_2 = CO_2 + 94 \text{ cal.}$$

but when heat is produced by the combustion of carbon monoxide (CO) only 68.2 calories are produced according to the equation $CO + O = CO_2 + 68.2$ cal. Here we have a difference in heat production of 25.8 cal. But this is precisely the amount which represents the heat produced when carbon is burned to carbon monoxide instead of to the dioxide, according to the equation

$$C + O = CO + 25.8 \text{ cal.}$$

Whatever the path followed to bring the atom of carbon into the condition of CO_2, the total number of calories produced is always 94.

On the other hand the equations given above show that the amount of heat set free in the production of one molecule of CO_2 depends upon the previous condition of the atom of carbon, *i.e.*, whether this is free or already in a state of combination. But in the body and in all food stuffs the carbon is always present in combination and hence the proper way to measure the heat produced is to find the heat of combustion of the compounds in question by means of Berthelot's calorimetric bomb, and it is this amount of heat which must be a factor in our calculations and not the amount derived from the combustion of pure carbon as Lavoisier supposed.

But in spite of the defects in his methods he was able to recognize the fact (collaborating with Seguin) that the quantities of carbon-dioxide produced and the amounts of oxygen absorbed increased with an increase in muscular labor. It was not until 1895, however, that the first calorimetric measures of a human being were made, the work being done in France by Langlois and the subject of experiment being a child. In 1911 the French physiologist, Lefèvre, gathered together all the known data upon the subject in a notable treatise.

CALORIMETRIC CHAMBERS

A calorimetric chamber is so constructed as to make it possible to measure exactly the amount of heat set free during the period of the experiment by the subject of the latter and to weigh and analyze all the waste product produced during the same time.

While a number of these have been constructed both here and abroad the typical example is that made by Professor Atwater and used since his death by Professor Benedict. The chamber consists of a sort of an air tight box having a capacity of 1,400 liters. The subject is seated in an armchair within this box which is connected with a pair of scales placed outside. In this manner the observer can readily follow the variations in weight.

Since the Atwater calorimetric chamber has been often described and is well known in this country, we shall omit the description of it and merely give a statement of some of the results obtained in this country and in France.

It has been found that with a normal diet suitably rationed, 90 per cent of the food taken is utilized in the organism. An interesting point is that a vegetarian diet produced results as good in this respect. at least, as one containing meat.

On the other hand it is claimed that the metabolism of alcohol taken into the system shows that this substance is not stored up to form part of the normal reserves of the organism. It apparently disturbs the regular mechanism of nutrition tending to alter the method in which the proteins are utilized.

SUMMARY

To sum the matter up the study of the development of heat in the human body has resulted in the obtaining of valuable physiological information. From the theoretical point of view it has shown that the process of metabolism is regulated by thermochemical laws, and it thus verifies the well-known principle of the conservation of matter and of energy. From the practical point of view it furnishes precise data concerning the laws which control physiology, of the digestion, and assimilation of food and of the elimination of waste matter and thus furnishes a basis for the application of these laws to diet, in particular, and to general hygiene.

HOW FAST CAN BACTERIA TRAVEL?

WHEN one examines, by means of an ultramicroscope, bacteria of different kinds existing in the same medium, one is struck by the very remarkable difference in the rapidity with which they move. Many kinds move very slowly, others dart with agility hither and thither, while some glide across the field of observation with such velocity that their passage resembles the flight of an arrow. The average rapidity of motion of any given kind of bacteria has been approximately determined. Signor Sanarelli, the Director of the Hygienic Institute in Rome, continuing the experiments of other investigators in this field, has established the fact that the velocity of motion of the cholera vibrion in a 24-hour-old agar-agar culture carefully covered with guinea pig serum and kept at a temperature of 25° cent. is on an average 0.125 mm. per second, *i.e.*, 7.5 mm. per minute or 45 cm. per hour. This microbe travels much faster than any other observed by this scientist. A curious fact in regard to this is that the cholera vibrion possesses as a rule. only one cilium, while other microbes have a number of these organs of motion as a general thing. Evidently, therefore, the rapidity with which microbes move does not depend upon the number of cilia they possess, as would naturally be thought.

Spiders Used in Medicine*

Ancient and Modern Pharmaceutical Uses of the Spider and the Spider Web

By J. T. Lloyd, Ph.D.

THAT insects and their by-products, such as shellac and honey, play an important part in the economy of man, is known to all. Perhaps, however, it is better known to the physician than to the layman, that a few spiders play their rôle in the practice of medicine. These spider remedies, like the insect medicines, are not of modern origin. In old works one finds frequent references to cobweb, which was then administered in the form of pills instead of the modern alcoholic pharmaceutical preparation, Tela Araneæ.

In the popular mind there is often little knowledge of the distinctions between spiders and insects, although the class *Arachnida* (to which the spiders, but not the insects, belong) contains several orders, such as the scorpions, that are closer akin to the spiders than are the insects. Most of these are so distinct in superficial appearance that there is little probability of their being mistaken for spiders.

If one will remember that spiders have four pairs of legs, apparently no antennæ, and that their head is not separated from the thorax by a neck-like constriction, there need be no trouble to distinguish them from insects; which have three pairs of articulated legs, one pair of antennæ, and head and thorax separated by a distinct "neck." In the class Arachnida, spiders may be easily separated from other orders by remembering that thorax and abdomen are separated by a short, slender stalk, and the abdomen is not segmented. In their nearest relatives, the mites, the thorax and abdomen are fused and sack-like.

Since very early times many people have looked upon spiders with unfounded dread and superstition. During the medieval period, "Tarantism," a contagious disease that was common in Southern Europe, especially Italy, was believed to have been started by the bite of a spider. The victims of this disease were possessed with an uncontrollable desire to dance. In our own day and among our own people it is not unusual to blame the bite of a spider for swellings or itchings of unknown origin, but when questioned the sufferer is invariably unable to give other evidence that a spider is responsible for the trouble, than the usual answer, "What else could have done it?" On this negative evidence the blame is fixed for about 100 per cent of the "spider bites" of our people.

With the possible exception of a single species in our Southern States (*Lactrodectus mactans*, a jet-black spider with markings of yellow or red), and the true tarantulas of the South-West, it seems safe to accept that there are no spiders in our country whose bite need be in any way feared. The writer has handled large numbers of our native spiders, as well as (during excursions in the tropics) hundreds of the "banana tarantulas," which are not true tarantulas, but harmless spiders of a different family. True tarantulas may sometimes, however, be found in banana bunches. In no case has the writer been bitten, and frequent attempts to induce spiders to bite the tender skin between his fingers resulted in failure. Others who have made this experiment with success report that the wound inflicted is no more painful than a slight prick with a needle. That spiders do inject a virus into their victims is indisputable, but it is in quantities sufficient only to paralyze an insect. Besides, it is injected so slowly that little, if any, could be secreted during the short interval that the "jaws" remain in the wound of an animal as large as man.

Spider Web.—All species of spiders are capable of spinning web, though far from all spin orbs or sheet-like webs for entrapping prey. Many species only throw out a "drag line" as they move from place to place, or drop from surface to surface, and never spin a more complex web, except in wrapping their egg masses.

The web material, or silk, is produced in large glands within the spider's abdominal cavity. In the glands the material is liquid or mucilaginous, but (except certain parts of the viscid silk) immediately hardens on exposure to the air. From the gland it passes to the exterior through silk ducts, which often open on movable, finger-shaped "spinnerets."

In all, spiders produce seven distinct kinds of silk; some thread-like, some band-like, some viscid, some dry. Though most spiders secrete more than one kind of silk, and some spiders secrete several kinds, no one spider secretes all seven. Each kind of silk originates in its own distinct glands and passes to the exterior through its own opening.[1]

For pharmaceutical preparations an attempt is made to collect the sheet-like webs of *Coras medicinalis* (*Tegenaria medicinalis*) from the corners of rooms in warehouses and kindred places. It is probable, however, that the webs of the several species of dwelling-inhabiting spiders enter into all pharmaceutical preparations of web. No collector of webs could be expected to possess technical knowledge sufficient to enable him to distinguish species. If he should possess the required knowledge, it would be impracticable for him to take the time to apply his training for the examination of each web collected. Nor is there need for such discrimination. No reason why the web of one species of dwelling-inhabiting spider should be of different therapeutical qualities from another, has ever been recorded.

We do not know that a chemical analysis of spider web has ever been made. Tests given pharmaceutical preparations, however, show an absence of sugar, but give a slight reaction to Mayer's test for alkaloid. This is true also of tincture we have prepared from fresh web. The therapeutic value of the preparation may be in part due to this alkaloid.

In the present-day practice of medicine the large spiders of the sub-family *Aviculariinæ*, commonly known as "tarantulas," or "bird spiders," are employed by Homœopathic physicians. Under the name of *Mygale lasidora* the Pharmacopœia of the American Institute of Homœopathy, 1897, p. 408, gives directions for preparing the tincture of the "whole spider." Other references to the preparation and use of Mygale (tarantula) are given in Allen's "Encyclopedia of Pure Materia Medica," 1877, vol. vi., and elsewhere.

Spider and Spider Web in Medicine.—At least since the time of Pliny (first century A.D.) literature on medicine abounds in references to the use of spiders and their webs. The ideas of most of the old authors concerning the medicinal use of spiders, as may be noted in the following quotations, seem little more than "charm medicine" or superstition. Let us quote:

Spiders.—"The fly-catching spider, wrapt in a line cloth and hanged on the left arm, is good to drive away a Quotidian, saith *Trallianus* (sixth century, A.D.). But better if any of them be boiled with oil of bay to the consistence of a liniment; if you anoint the arteries of the wrists, the arms and temples before the fit, the fever abates and seldom comes again. *Koronides or Koranus* (King of Persia, who wrote a work on natural history). A spider bruised with a plaister and spread on a cloth and applied to the temples, cures a

*From *American Journal of Pharmacy*, Jan., 1921, and reprinted in *Chemical News*, April 8, 1921.

[1]A careful and interesting account, written in non-technical language, of the habits, anatomy, and classification of spiders, may be found in "The Spider Book," by John Henry Comstock: Doubleday, Page & Co., 1912.

tertian. *Dioscorides* (first or second century, A.D.). The spider called Lycos, put in a quill, and hanged on the breast doth the same. *Pliny* (first century, A.D.). That house spider that spins a thick fine and white web, shut up in a piece of leather or a nut-shell, and hanged to the arm or neck, is thought to drive away the fits of a quartane. *Dioscorides* saith he proved it to be true. Three living spiders put into oil, let them presently boil on the fire, drop some of that oil warm into the ear that is in pain, and it profits much. Or press out the juice of spiders with juice of roses, and put it in with wool. *Marcellus Empiricus* (380-408, A.D., or later). Pliny bids infuse them in vinegar or oil of roses and stamp them and then drop some into the ear with saffron, and it will still the pain certainly: Dioscorides affirms as much. *Sofratus* . . . saith, that Cranacolapsus (a certain spider) drowned in oil, is a present remedy against poisons, as the Scholiast of Nicander (second century, B.C.) professeth. Aetius (about 500 A.D.) for suffocation of the mothers, applied a cerate of spider to the navel, and said it did great good."

Spider Web.—"The spider's web is put into the unguent against Tetters, and applied to the swellings of the fundament, it consumes them without pain. *Marcellus Empiricus.* Pliny saith it cures runnings of the eyes, and laid on with oil, heals up wounds in the joints. Some rather use the ashes of the webs with Polonia and wine. Our chirurgians (surgeons) cure warts thus: They wrap a spider's ordinary web into the fashion of a ball, and laying it on the wart, they set it on fire, and so let it burn to ashes, by this means the wart is rooted out by the roots, and will never grow again. Marcellus Empiricus was wont to use the web of spiders found in the Cypress tree in a remedy for the Gout to ease the pains."—Mouffet, "The Theater of Insects," 1858, p. 1023.

A few of the early writers, like Antoninus Pius, and more during the medieval period, used the web to stop the flow of blood. For this purpose it was also used by the American Indians, as well as in domestic practice, no doubt with a real value. For example:

"Antoninus Pius (86-161, A.D.) was wont to say, that the quirks of sophistry were like to Spiders' Webs, that had a great deal of art and ingenuity in them, but very little profit. But how often hath the blood run forth from the body most miserably by a fresh wound? Yet it had been easy to have stopped it by laying on a spider's web."—Mouffet, "The Theater of Insects."

"*Telia Aranearum*, Cobweb. Everyone knows what this is, and how produced. It appears not in medicinal prescriptions, but as accident, for want of other helps, has taught its use to common people for stopping blood in a fresh wound. And this it seems to do by its extraordinary fineness; which makes it adhere to, and stop up the mouths of the vessels, so as to prevent the effusion of their contents."—Quincy's Compleat English Dispensatory, 1749.

"*Aranearum Telae Pharm. Edinb.*, Cobwebs.—These are applied by the common people for stopping the bleeding of wounds; which they effect, not by any styptic power, but by adhering to the part, and closing the orifices of the vessels."—Lewis' Materia Medica, London, 1768.

"The web astringes and conglutinates, and is, therefore, vulnerary; restrains bleedings, and prevents inflammation. The country people have a tradition, that a small quantity of spider's web, given about an hour before the fit of an ague, and repeated immediately before it, is effectual in curing troublesome, and sometimes obstinate distemper. This remedy is not confined to our own country, for I am well informed that the Indians about North Carolina have great dependence on this remedy for agues, to which they are much subject; and I am acquainted with a gentleman long resident in those parts, who assures me he was himself cured by it of that distemper. And, indeed, experience confirms the efficacy of this medicine in the cure of agues."—James, "New English Dispensatory," London, 1747.

In May, 1809, the *Medical and Physical Journal* of London published a long article by Dr. Robert Jackson, calling to the attention of the profession the medicinal use of spider web, or cobweb, in the treatment of intermitting fevers. Frequent references have been made to this article by subsequent publications in Europe and in America. After Dr. Jackson's publication, the use of spider web in the treatment of Malarial fevers seems to have been neglected until about 1865, when articles by Dr. L. M. Jones appeared in the *Lancet and Observer*, Cincinnati, and in Jones and Scudder's "Materia Medica." These again brought it to the attention of physicians:

"In asthma it is said to allay irritation, tranquilise the system, and act like a charm. In spasmodic complaints of females; in chronic hysteria, and other diseases attended with morbid irritability of the nervous system, it has been advantageously employed. Dr. Webster, of Boston, has found it beneficial in rheumatic affections of the head, asthma, and chronic coughs. He says it produces a pleasant delirium and exhilarating effects resembling the nitrous oxide gas. Dr. Gillespie used it in obstinate intermittents successfully, after other remedies had proved ineffectual. He thinks it more effectual than bark or arsenic.

"Dose.—Gr. v to vj, in pill; repeat every three or four hours. Dr. Jackson thinks a dose of gr. v produces nearly the same effects as one of gr. xx."—Jones and Scudder's "Materia Medica."

After the articles by Dr. Jones, the use of web gained constantly in the favor of many physicians. Present-day literature contains numerous testimonials to its use in the treatment of intermittent fever, and in diseases of sudden appearance, when there is a tendency to congestion, with cool clammy skin, cool extremities, and cold perspiration.

Among the patients of the late Dr. L. A. Perce, of Long Beach, California, were many tourists afflicted with malaria. Some of these had been, to use his words, "dosed with quinine until it had lost its effect." For such patients he states that he employed tincture of "Tela Araneæ."

Until comparatively recently, as already stated, the web was administered in the form of pills, instead of in the alcoholic pharmaceutical preparation, "Tela Araneæ," of today.

MOLTING IN SONG BIRDS

THE following remarks on molting habits of song birds were made by Dr. Stressmann of Munich at the meeting in Berlin on Oct. 10, 1920, of the German Ornithological Society in the Museum of Natural Science:

Among the small birds known as "*Schmätzer*" the *Oenanthe hispannica* and the *Saxicola rubicola* molt only once a year, while the *Oenanthe oenanthe* and the *Saxicola rubeara* do so twice a year. All of the Eurasian pipits molt semi-annually, whereas the neo-tropic varieties do so but once yearly.

The mock-nightingale, which lives in our latitude, molts not only in the fall, but in the winter also, in the zone of migration, but the birds which make their home in Corsica, on the other hand, do not molt in the winter. Among the buntings only the crested bunting (*Kappenammer*) and the ortolan, which are definitely migratory in habit, molt both in fall and in winter, while the other kinds which are stationary birds and birds of passage have only one yearly period of molting. The blue thrush molts once a year and the stone thrush twice. But the idea which might be deduced from these examples that the semi-yearly molt is peculiar to migratory birds is contradicted by the annual molt of the yellow-thrush and the swallow, as well as by the semi-annual molting of many stationary birds. A peculiar intermediate habit is found in the blue-throated warbler which molts merely the feathers of the throat when in its winter haunts in order to don its azure wedding garb. Many young birds molt their entire plumage, others lose only the small feathers, retaining those of wings and tail. Among the former are larks and swallows, etc., etc., while the latter include ravens, thrushes and the buntings except the gray bunting.

Flowers That Flash

So-Called "Electric" Flashes of Light Given Off by Certain Flowers

THE phenomenon of cold light is rather more familiar in the animal than in the vegetable kingdom, as in the well-known cases of the glow worm, the firefly, and certain tropical beetles, as well as a number of luminous fishes. However, there are numerous interesting cases of plants which are, likewise, luminous by night. The weird shine often seen in forests upon rotting wood is generally due to the common leaf fungus known as the *Hallimasch.* A similar fungus from Brazil, having the charming name of "Flor de Coco," gives off a pale green light by night, sufficiently strong to be used as a night lamp. In eastern Australia the *Panus incandescens* emits an emerald gleam and a similar glow is given forth by the *Tlcurotus candescens*, the *Agaricus oleraceus* and *A. illuminans*, the *Polyporus noctilucens*, and many others. But while all these fungi give off more or less light in the dark, attempts to make use of them as night lamps are not very successful, since they soon die when removed from the wood upon which they feed and the preparation of artificial culture in which to grow them has so far not been found very practical.

But there is still another kind of luminosity in plants—we refer to the so-called electric flashes of light given off by certain flowers. This phenomenon was first described by Linnaeus' daughter, Elizabeth, in 1762, in blossoms of the Indian cress. But it is a matter of some dispute among the learned us to just what Elizabeth Linnaeus saw. A German professor, Dr. F. Thomas, published a monograph in 1914 upon the subject, setting forth his views that the so-called "phenomenon of Elizabeth Linnaeus" is identical with what is known as the Purkinje "phenomenon," but he was hotly taken to task by another learned gentleman, Mr. A. Schleiermacher in the *Biologisches Centralblatt* (Berlin), for January, 20, 1915, from whom we quote the following paragraphs:

"The Purkinje phenomenon is the name applied to the circumstance that objects which are red or orange in color when seen by twilight appear to be blue and green. It has been observed, however, that this phenomenon does not occur in the *Fovea centralis* (where only cones are found). When, therefore, some bits of orange-red paper or orange-red flowers are seen against a green or blue background, those which are seen in a straight line (whose image consequently falls upon the Fovea) appear to be brighter and more vivid in color than those which are viewed slantingly, and which appear to be of a dark reddish brown as detached against the comparatively brighter background. When the glance wanders from one of the orange-colored objects to another the latter becomes brighter since it is now the one in the line of direct vision. So long as the direction of the gaze remains unaltered, the object received by the *Fovea centralis* will remain bright, while the others appear to be dark. But this phenomenon could by no means be described as an appearance of lightning or 'flashing,' as the Swedish word employed by Elizabeth Linnaeus should, in my opinion, be translated.

"The phenomenon observed, described, and illustrated by me was utterly different—it was namely, a momentary side-wise brightening or whitening which appeared in some of the poppy blossoms, seen whenever the glance traveled rapidly and horizontally at a height of 20 to 40 cm. above the flowers, which were at a distance of about 2 meters. When the gaze was fixed upon any one of the flowers separately, the phenomenon ceased to appear. I was able to perceive the same phenomenon somewhat later upon observing by twilight an orange-red scrap of paper upon a blue background and convinced myself of the correctness of my first impression in spite of the fact that conditions were more unfavorable on account of its being winter time in the latter case. Moreover, I repeated the experiment last summer with colored scraps of paper with the same success—a success obtained likewise by many other persons, including far-sighted and near-sighted ones as well as those with normal eyes.

The interest roused by the description given by Elizabeth Linnaeus of the flashes of light or "lightning" she glimpsed proceeding from the vivid orange flowers of the Indian cress caused many other observers to watch for this phenomenon in these and other flowers, and similar observations have been reported as seen in fire lilies, helianthus, tropaeolum, tagetes and ringelblumen. The Swedish botanist, Fries, saw similar flashes from the flowers of the oriental poppy and the great Goethe himself, who was an ardent botanist, confirmed this, saying he had seen something flame-like flashing from the flowers; the poet even tried to explain the phenomenon by his theory of colors. According to a writer, Heinz Welten, writing in a recent number of *Ueber Land und Meer*, there have been many reports, too, of miraculous fires upon pines, ash trees, and Erlen, clinging to the buds and pointed leaves on warm summer nights.

Mr. Welten has the following explanation concerning this phenomenon to offer:

"All of these phenomena have their origin in the atmospheric electricity of which the air is full, especially before storms and which falls from the points of the leaves. It is even possible to occasion the phenomenon artificially, as when, for example, a specimen of the *Tropaeolum ma jus* or a begonia plant growing in a pot (the earth in which must be pretty dry) is placed upon an inverted tumbler or a lump of wax in order to insulate it, and the plant is then charged (in a dark room, of course) by means of an electrical machine. If the negative pole of the machine is connected with the earth in the flower pot and the positive pole is then brought near to the plant, small beads of light will appear upon the points of the leaves. But when the plant is positively charged, on the contrary, small plumes or feathers of light will stream from the leaf points. This experiment was first carried out on a large scale by the botanists, Molisch and Tubeuf . . . it affords a pretty novelty for an evening garden party.

"The phenomenon described is explained by the recent theory of duplicates of von Kries as a secondary image or 'ghost,' due to the primary excitation of the color-blind rods which sets in about 1/5 of a second later than the excitation of the cones. Because of the fact that there are no rods in the Fovea, this colorless (having a whitish gleam) after-image is observable only upon the periphery which corresponds precisely to my observation of the side-wise flash from the flowers. It thus becomes obvious that Dr. Thomas and I were really engaged in observing two entirely different phenomena."

Mr. Schleiermacher cannot resist the remark that he finds it very strange that neither Dr. Thomas nor his assistants were able to see the "secondary image" described above, adding that to his own knowledge many other persons had observed it and clearly described it, though they have received no previous information concerning it, thus precluding the idea that there might have been any psychological self-deception. He quotes a letter from a professor of physiology in Innsbrück in special support of his statement. He closes his article by describing the conditions under which this secondary image is most clearly seen, so that any of his readers may test for himself its reality and convince himself that it is entirely different from the Purkinje phenomenon with which he believes Dr. Thomas has confused it, in the following words:

"Upon a sheet of non-glossy paper, ultra-marine blue in color (the larger this sheet the better) lay a scrap of paper of any desired shape (square, round, etc.), orange-red in color and about 7 cm. long. An easy way of obtaining paper of the

proper color is to take an ordinary piece of filter paper and place it in an aqueous solution of flavein to which has been added a small amount of brilliant crocein. Then, look at the orange-colored piece of paper while standing at a distance of from 1 to 2 meters, the gaze being fixed at the upper edge of the large sheet of paper, *i.e.*, at a distance of 20 to 40 cm. above the orange-colored spot, the eye being moved rapidly along the sheet of paper. This repeats in all essentials the degree and color of a twilight sky when there are no clouds and at about ¼ to ½ hour after sunset, the degree of light being one that makes reading still possible without too great a strain on the eyes. If these directions be followed the secondary image will appear to move toward the red spot in the same direction as the motion of the eye. The luminous flash is frequently observed, even when there is a merely involuntary movement of the eye in the vicinity of the red spot, or upon the edge of the large sheet of blue paper; it is even sometimes seen when the sky is cloudy. A reddish evening twilight is, upon the contrary, unfavorable to the observation of the Purkinje, but the full brilliance of the flash is best observed when the sky is as clear as possible with a 'blue' luminosity. It is because these exceptionally favorable conditions so rarely occur in our land, in my opinion, that this effect of the lightning flashes from flowers against the background of foliage is so seldom observed.

In 1799 Goethe made an observation, the flower in question being likewise the perennial poppy, which practically agrees with my own . . . the only difference is that he describes the color of the secondary image not as whitish but rather as of the color complementary to orange—in his letter to Schiller he speaks of it as a very clear green.

"That the secondary image under certain conditions appears faintly colored, I have, myself, observed upon the color of Dr. Thomas, where it assumed a bluish tone against the more gray-blue background. This indicates that the sides, the colorless stimulus of the rods, there is a faint colored complementary subsequent image of the cones. The flashes are, indeed, observed most clearly upon a zone of the retina, wherein the colors are still very definitely separable and where, therefore, numerous cones are still present. In a sensation due purely to excitement of the rods, black scraps of paper ought to flash quite as well as the red (dark to the rods), provided they did not reflect more blue light. It is my observation, however, that the image is fainter when the black scraps of paper are used than in the case of those of a poppy red color. Another striking feature is, that with a *green* background the image is much fainter than with the blue one, although the most recent determination of the maximum of sensibility for the rods in green is about 515 milimicrons μ. . . . In higher latitudes than our own where in summer they rejoice in "white nights" favorable conditions of illumination appear to occur much oftener than in Germany; Fries, for example, was able to observe the "lightning flashes" during a period of a week and a half.

Phosphorescence

Existence of Solid Solutions in Light Stones

By T. A. Marchmay

THE word phosphorescence is somewhat loosely employed to signify the luminous rays given off by certain bodies unaccompanied by heat, and also certain other phenomena of luminiscence which are really quite different in character, such as the luminescence exhibited by selenium and certain other substances after exposure to sunlight or strong daylight. These latter phenomena are, of course, instances of borrowed light, and not of what is known as cold light, which is essentially a case of very slow combustion, with an ideal utilization of the calories of the substance consumed.

Every body must, as Walther Kuehn observes, writing in a recent number of *Umschau* (Frankfurt) be raised to a certain degree of temperature in order to emit rays of light, and a practical example of this fact is found in arc lights as well as electric bulbs and also in the mantel now in general use to increase the luminosity of gas flames. But men of science and, for that matter, the laity likewise, have long been familiar—certainly since the times of the Renaissance, with certain substances which emit rays of light of various color, according to the nature of their chemical composition. It is very recently, indeed, that scientists have been able to explain the cause of this baffling phenomenon, though it has aroused absorbed interest for centuries. The name phosphorescence was applied to this phenomenon because of the well-known fact that white phosphorus emits this sort of cold light at ordinary temperatures. It is now known that the production of this light in phosphorus is due to the action of oxygen, which slowly combines with it. If the phosphorus, however, be exposed to the air for even a comparatively short time, its temperature gradually rises until it reaches a point where it bursts spontaneously into flame, burning with great violence and brilliance. The writer has only too good reason to remember this fact, since she was severely burned upon one occasion while exhibiting a piece of phosphorus to a class in chemistry. One of the students touched the mass lightly with the point of her pencil, and even this slight amount of friction was enough to set the softly glowing mass off instantaneously.

The charming green gold light flashed by fireflies and glow worms is also due to a slow oxidation process, and here nature intervenes to prevent the combustion from ever becoming too rapid.

Let us first discuss, however, the first named sort of phosphorescense. Some quite remarkable discoveries concerning the nature and cause of this have been recently made, especially by the Heidelberg professor, Dr. Lenard. This authority first investigated the composition of the so-called artificial "light-stones," which were first prepared by entirely empirical methods about the beginning of the present century, and he discovered that they obey certain laws of quite surprising character.

To begin with, every light-stone must contain three components:

1. A sulphide of the earthy alkalies, *i.e.*, a compound of calcium, barium, or strontium, with sulphur.

2. A heavy metal which is present in extremely minute quantities in the form of a readily soluble salt; these include bismuth, manganese, nickel, copper, uranium, thallium, and platinum in especial.

3. A flux, such as salts of sodium and potassium, fluorspar, etc.

These three components bear an exceedingly simple relation to each other: the heavy metal exists in the form of a solid solution in the sulphide of the earthy alkali; when the molecules of the body exist in a state of fine division within a fluid, *e.g.*, as in the case of sugar and water, we speak of a *solution*, but in an exactly similar manner we may consider that we have a *solid solution* when one solid body exists in a state of fine division throughout the mass of another solid body. These relations have been explained and made particularly lucid by the work of Waentig. He produced light-stones with constantly increasing percentages of heavy metals;

each of these was heated for periods of ten minutes and ninety minutes and the intensity of the light emitted by them was then examined. At 700° C. and with a longer period of heating there are first dissolved 4/80,000 and a saturated solution is formed; thereafter, a super-saturated solution is gradually formed; the sulphide has reached its maximum degree of capacity for absorbing the metal and in consequence of this particles of the metal begin to separate out upon the surface of the light-stone, the intensity of the latter being at the same time strongly diminished. At 800° C. and a period of heating ten minutes longer, the same phenomenon appears, but in a heating period of 90 minutes on the other hand, the curve rises abruptly, so that it would seem as if all of the metal added (*i.e.*, 16/80,000) is dissolved.

But here another factor makes its appearance, namely, the evaporation of the metal at a higher temperature, which thus practically cancels the disturbing influence of the separation out of particles of metal upon the surface. This was especially obvious in the curves for 900° and 1,000° C. In any case a comparison of the four curves for a heating period of 90 minutes shows that the most advantageous method of preparation is that at 800° C. at which temperature, too, Waentig secured the best results.

This theory of the existence of solid solutions in light-stones has recently received fresh support from experiments made by the Hamburg physicist Walter. He exposed a light-stone to intense light, a part of which was absorbed, while another portion was transmitted and again sent forth. By means of a complicated apparatus he succeeded in determining the amount of light transmitted, which, divided by the thickness of the surface of the light-stone, yielded the so-called transmission co-efficient; it was proved that these numbers have the same magnitudes that are found in ordinary solutions as, for example, in fluorescein in water, which furnishes a further proof of the dissolved condition of the substances.

But science has been concerned for a long time, not only with the composition of these bodies, but with the nature of the process, until finally Lenard, making use of the implements provided by the results of the modern atomistic theory and of theoretical physics, succeeded in explaining the essential character of the phenomenon. He first examined whether the intensity of the emitted light and the wave length of the exciting light are in any way related; pretty much all the practical light-stones were tested and the results represented in diagrammatic curves. Thus it was found that in a calcium sulphide having an addition of nickel, a spectroscope gave the following results: Besides the normal spectrum there appeared four clearly perceptible dark lines or bands, which occupy the positions of 635, 567, 527, and 440, 10^{-6} mm. wave length. It was proved to be true in all of the many cases, some of which were very complicated, that the wave length of the exciting light is always smaller than that of the excited light, or in other words: The curve representing the latter always lies behind that of the former and never coincides with it! This surprising law had been discovered by Stokes in fluorescing bodies, but was now found as we see, to hold good in phosphorescence.

In a later work thus Stokes' law finds itself supported, which fact, however, demands a more extended explanation. The emission of the light takes place from so-called centers of emission, and these are molecules possessing approximately the chemical formula $Ca_x\ Cu_y\ S_z$; according to the form of the carbon rings present which are extremely wide spread in organic chemistry, there are formed within it closed chains, such as —S—Ca—S—Ca—S—, etc.; but now the atoms of the added metal attach themselves to the free arms of the sulphur atom, so that a light stone molecule may be regarded as having approximately the following constitution:

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—Ca—S—Ca—              —Ca—S—Ca—
     ‖        or else       /\
     Cu                   Cu  Cu
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From such a complex a ray of light falling upon it splits off an electron as the elementary quantum of electricity, which after a certain lapse of time, which depends upon conditions to be described later, returns to its point of emission in a vibratory movement. This "light electric" electron induces a sympathetic vibration in another electron, the "emission electron"—in other words, therefore, through the emission of a ray of light and a repetition of this process, the whole phenomenon comes to a standstill. As we see, the two kinds of electrons can be compared with two electric vibration circuits, such as are employed in wireless telegraphy, one of which excites the other to a sympathetic vibration by means of resonance. In any case the emission electron will send out light at the moment when its duration of vibration coincides with that of the light-electric electron; that of the latter becomes constantly less until it is finally smaller than that of the first—or, expressed in other words: The wave length of the exciting light is shorter than that of the excited light which constitutes a new proof for the above mentioned Stokes' law.

By means of the concepts thus developed we now find that it is also possible to explain the characteristic behavior of the light-stones at various temperatures. When a light-stone is first illuminated and then placed, for example, in liquid air or in a mixture of ether and carbon dioxide it is completely extinguished; but if it is now taken out of the freezing mixture it slowly emits a faint light, while if it is then heated in a Bunsen burner it suddenly begins to emit a very intense light, following which it entirely loses its capacity to emit light. Here, then, we have three different conditions to deal with:

1. The condition of cold, in which the electrons are split off without returning and the energy is in a measure stored up: the body emits no light.

2. The normal condition of durability, in which the electron slowly returns: the result is a quiet uniform emission of light.

3. The condition of heat in which the electron returns with great rapidity: in this case the light-stone emits an intense light until the vibrations have ceased.

Hence it must be essentially possible to incite the light-stone to artificial illumination of light, since the stored up energy must inevitably issue forth again without remainder, in which process, of course, a certain fraction is lost in the form of heat. Unfortunately, all light-stones thus far prepared lose their power so rapidly that we have not as yet succeeded in proving this in practise. Herein lies the problem of the most weighty importance: namely, the postponement so far as possible of the loss of power of the light-stone and the reduction of the capacity of absorption by means of the addition of a suitable flux.

RAPID DETERMINATION OF ALCOHOL PERCENTAGE.

A NOTE published in the *Annales de Chimie Analytique Le Genie Civil* (Paris), for Feb. 21, 1921, which quotes from the *Bulletin de l'Association des Chimistes de Sucrerie et de Distil*lerie, gives a rapid method of determining the amount of alcohol in a given liquid. The process consists of treating a known quantity of alcoholic liquid placed in a glass tube graduated in tenths of a cubic centimeter with an excess of anhydrous potassium carbinate, and adding water thereto in case the percentage of alcohol is supposed to be greater than 90 per cent. After the mixture has been shaken or stirred thoroughly it is allowed to stand, whereupon it separates into three layers: a lower layer consisting of solid potassium carbonate; a middle layer consisting of an aqueous solution of potassium carbonate; and finally, an upper layer of alcohol and water, corresponding to the formula $4C_2H_5OH,H_2O$. The saturated aqueous solution of potassium carbonate which forms the middle layer contains 0.00275 volumes of hydrated alcohol per cubic centimeter. The composition of this hydrated alcohol has been definitely determined by means of a densimeter. The note contains the formula indicating the percentage of alcohol and gives the details of the operation.

Photographing Chemical Reactions

New Method of Recording Reactions Accompanied by a Variation of Pressure

At a recent meeting of the French Academy of Sciences (March 29, 1921), M. H. LeChatelier presented a note by M. Pierre Jolibois concerning a new method devised by him for recording chemical reactions accompanied by a variation of pressure. We present below an abstract of the process for whihch we are indebted to *Le Génie Civil* (Paris) for April 9, 1921:

The double galvanometer of M. M. LeChatelier and Saladin enables us to record by means of the camera the critical point of metallic alloys by passing through each of the respective galvanometers which compose the apparatus:

1. A current proportional to the temperature of the specimen;

2. A current proportional to the difference between the temperature of the specimen and that of a body which undergoes no transformation whatever during the period of time involved. M. Jolibois has sought to extend the use of this instrument and to adapt it to the study of certain chemical reactions. For this purpose he has devoted his attention to those reactions which are effected with a liberation of gas producing a variation in the pressure.

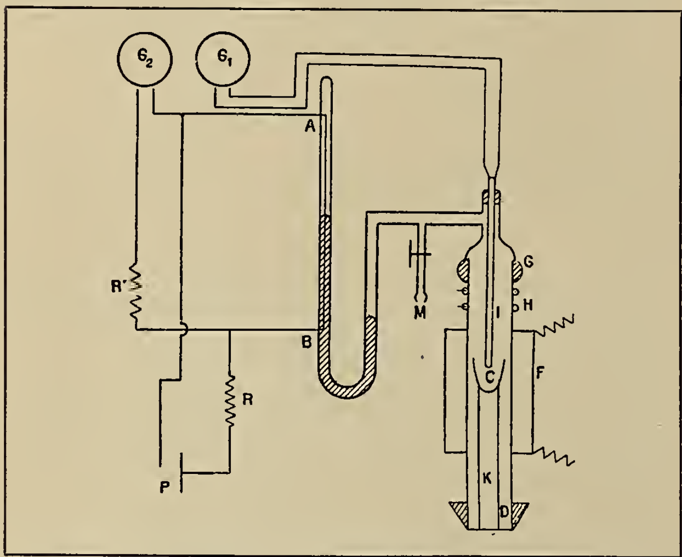


FIG. 1. DIAGRAMMATIC ARRANGEMENT OF APPARATUS FOR PHOTOGRAPHING CHEMICAL REACTIONS

The problem consisted in transforming a pressure into an electric current of an intensity adapted to set in action a galvanometer in order to obtain the curve which connects the temperature and the pressure. The author succeeded in doing this in the following manner:

The apparatus in which the reaction is performed communicates with the mercury manometer shown in Fig. 1. In the barometer leg A B of the latter a fine platinum wire is stretched, the wire being 50 cm. in length, about 0.1 mm. in diameter. Through this wire a current of electricity constantly passes, and the galvanometer which records the pressure is connected in parallel with the wire A and B. When the mercury rises in the leg A B the length of the wire traversed by the current is diminished, as likewise the intensity of the current in the galvanometer G_2. A simple calculation shows that the current is practically proportional to the length of the wire outside the mercury, when the resistance R and R' are large as compared to that of the wire.

The galvanometer which gives the temperature is graduated in the usual manner by recording the known fusing point and boiling point. The galvanometer G_2 has been graduated experimentally by measuring with a cathetometer the difference in level of the mercury and in causing a line to be described at the luminous point at a constant pressure and at a variable temperature.

The material to be studied is placed in a crucible C composed of some suitable substance. The crucible is held by means of a tube K in the center of a varnished porcelain tube heated electrically by a furnace F. To the upper part of the porcelain tube there is cemented a piece of glass G, through which passes a tube I made of transparent fused silica and designed to contain the thermoelectric couple.

The cement is cooled finally by a current of water H. The lower part of the tube is closed by a porcelain crucible D in the bottom of which are placed the absorbent reagents which serve to facilitate the study of the reaction (P_2O_5 in the case of the reduction of an oxide by hydrogen).

A lateral branch M enables the operator to procure a vacuum in the apparatus or to introduce the gases required for the experiment. This apparatus makes it possible to record in a single operation the tension of the vapor of a body and the dissociation tension of a compound. If a timepiece be added to interrupt periodically the luminous pencil of the double galvanometer the time will be inscribed upon the photographic records. In this manner it becomes possible to study the comparative rapidity of reactions and to measure, for any given rate of rise in temperature, the temperature at which any given reaction exhibits an appreciable rapidity (the reduction temperature by hydrogen, by carbonic oxide, reduction of oxides by carbon, etc.). Moreover, when several compounds are formed during a reaction the deviations in the curve enable the observer to predict the number of those in certain cases.

A still more general character can be imparted to this device. The author has constructed an apparatus which enables him to record the time upon one of the galvanometers by an analogous principle based upon the employment of a Mariotte's vase and a platinum wire whose useful electrical length is capable of variation.

RELATION BETWEEN BOILING POINT AND FUSION POINT

The well-known French scientist, M. Maurice Prudhomme, has recently made known his discovery of the existence of two simple relations between the critical, absolute temperatures (T_c) of the boiling point under a pressure of one atmosphere (T_1) and the fusion point (T_f). Writing in the *Journ. de Chim. Phys.*, Vol. XVIII, No. 3, p. 307, Oct. 31, 1920, he states that the first relationship may be expressed in the following equation $T_c/T_1+T_f=C$, in which C is a constant for the groups of elements O and VII, the families of similar or analogous bodies, hydracids, halogen derivatives of the carbo-hydrates (methane, ethane, benzene) the chlorides of the metals in Group IV, chlorides of the metalloids in Group V, alcohols, ethers, organic acids, nitrates, etc.

The value of C varies but slightly from one series of bodies to another and differs from unity only by a few hundredths. In the case of certain bodies, H_2O, PH_3, CH_3Br, C_6H_5Cl, $CO(CH_3)_2$, C is equal to unity, and in this case $T_c=T_1+T_f$. The absolute critical temperature is equal to the sum of the absolute temperatures of the boiling point and the fusion point.

The second equation is as follows:

$T_f(T_c-T_f)/T_1(T_c-T_1)=C_1$, in which C_1 is a constant, like C, for the same series of bodies. The values of C_1 and C differ very slightly from each other: in certain cases, indeed, they are identical, in particular when $C_1=1$, since in this case $T_c=T_1T_f$.

By means of these two rules it is possible to calculate the critical temperature of metals with approximate precision.

The Universal Language

Ancient Musical Instruments and Modern Instruments Developed by Primitive Peoples

By H. A. Harges

MUSICAL sounds are commonly produced in one of three ways: by the vibration of one or more strings of gut, metal or some substitute therefor; by the movement of air columns in tubes or irregular shapes, and by the vibration of solid or hollow bodies of resonant material. While there are hundreds of types of musical instruments and thousands of variations, most of them fall naturally into the three "root classifications" given above. Take, for example, one of the simplest of musical instruments—the drum. We are apt to think of a drum as the ordinary bass drum, or kettle drum of the orchestra, while to the military man, the snare drum comes at once to mind. How few people know that there are other types of drum even in our midst to say nothing of those used by savage or semi-savage peoples.

Drums may be scientifically divided into three classes:

First: Single skin on some kind of a frame open at the bottom. Most savage drums are of this class and the tambourine of the Spanish dancer and the Salvation Army lassie are embraced in this classification.

Second: Single skin on a closed vessel as a kettle drum. This instrument is about as unstable as a quicksand and the poor drummer of the orchestra must be constantly tightening up the stretchers somewhere. Instruments of percussion of this kind are found among those of many savage people.

Third: Two skins disposed at either end of a cylinder as in the child's drum and the military drums.

As a noise producer the drum has no equal and probably for this reason has been an especial favorite among primitive people and cymbals and gongs are close followers. It is probable that the earliest instruments were those of percussion, hence we have cited the drum as a typical instrument.

The earliest known instruments were probably suggested by the clapping of hands, stamping of feet, of which habits the human race have never divested themselves of. The resonance of hollow trees under the impact of blows probably also had its effect among the feeble tone-development of early peoples. The "bones" may be regarded as a very early instrument and originally they were four pieces of the ribs of oxen or horses. These in turn were followed by wind instruments which may have been suggested by the sighing of wind through standing reeds and bamboos. Such instruments were probably first used in the chase and finally for amusement. The human ear was, of course, uncultivated and it took a long time to recognize variations of pitch, tune and time. The cave-dwellers had stone gongs and bone flutes and we know from the wall paintings and sculpture, the Egyptians and Babylonians had brought such instruments to a reasonably satisfactory state of development. The Assyrians were a military people and their music, which was very military and strident, included trumpets, drums and the ancestor of the zither.

The Egyptians had schools of music and there were orchestras with a conductor! Stringed instruments predominated. The harp was the national instrument and we find it in all sizes from those carried in the hand to immense temple harps. Flutes and drums were also in use and we find pictures of a rattle or clapper which the Greeks also used in a more refined form. From all accounts the Hebrews were the best musicians, but the Children of Israel made no graven images and as the translation of the Bible in the time of James I. was made before the days of biblical archaeology we see Hebrew instruments as through a glass darkly. There is a very interesting exhibition of musical instruments of modern Palestine in the Case Memorial Library of the Hartford Theo-

From the Standard Bible Dictionary

MUSICAL INSTRUMENTS FROM THE SUVIA DAVISON PATON COLLECTION IN HARTFORD THEOLOGICAL SEMINARY

1—*Kitâra* (Lyre); 2—'*Ûd* (Mandolin); 3—*Kanûn* (Zither); 4—*Tambûra* (Lute); 5 and 6—*Rabâib* (Fiddle); 7—*Arghûn* (Bagpipe); 8—*Shubâb* (Flute); 9—*Nakkura* (Kettle-drum); 10—*Daff Derwîs* (Dervish's Tambourine); 11—*Daff* (Tambourine): 12—*Derbekke* (Hand-drum); 13— *Nakkara* (Kettle-drum); 14—*Nây* (Flute); 15—*Shôfâr* (Jewish Ram's Horn); 16—*Bûk* (Horn); 17—*Nây* (Flute)

logical Seminary and the writer, through the courtesy of Prof. Thayer, was recently enabled to examine the collection in detail. The following description of musical instruments of the Bible is from the Standard Bible Dictionary (Funk & Wagnalls, and is republished by permission).

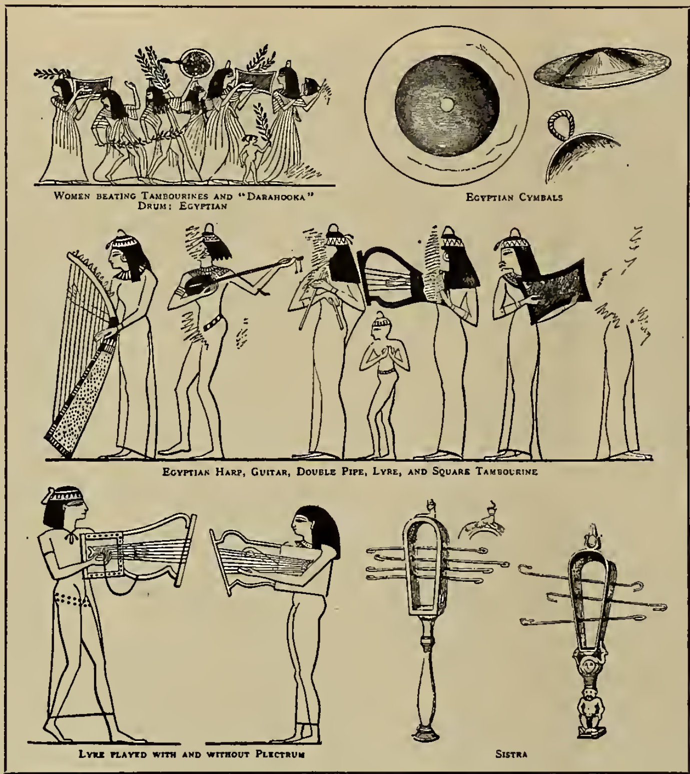
"The instruments named are representative of the natural groups that are observed everywhere: namely, those that are struck or shaken (percussive or pulsatile), those that are blown with the breath (flatile), and those with strings that are twanged. The Hebrews are not known to have had any form of viol—a stringed instrument played by the friction of a bow—though on this point our information may be defective.

"1. Of instruments struck or shaken there are four or five: (a) The tabret or timbrel, was probably a small bowl-shaped drum, or possibly a hoop-shaped tambourine. Of seventeen references, a decided majority are in connection with merry-making, and the rest religious, in the hands of the prophet-gild, or of worshippers. It appears usually with the harp, often with the psaltery or pipe, rarely with the cymbals or trumpets. (b) The cymbals were either hollowed metal cups held in the hands or little plates fastened to the fingers (castanets). All the ten or more references are in religious use, and all but one in the later histories. In one passage they are described as made of brass. They occur usually with the harp, psaltery, and trumpet, and with song. (c) Some pulsatile instrument (Revised Version *castanets*) which occurs only in the story of the upbriugiug of the Ark, was probably the Egyptian *sistrum* (a loop-shaped metal frame with loose, jingling rods). (d) Bells or jingles, as part of the trappings of horses, are once named.

"2. The flatile instruments represent both the flute and the trumpet classes. (a) The pipe was either a direct flute or flageolet, or possibly an oboe, doubtless made of cane or wood. Of the five references, one shows use by the prophet-gild and the rest are social. (b) Another pipe (*organ*, authorized version) is supposed to be some form of Pan's-pipe or *syrinx* (a set of graduated tubes of cane). Of the four references (all with mention of the harp), that with Jubal's name seems generic for all kinds of wood-wind instruments, and the rest are poetic. (c) The ram's horn or horn is but rarely mentioned, but was probably common as a rude instrument for signals and noisy demonstrations. (d) The curved trumpet, *shophar*, was probably derived from the foregoing, but possibly was often made of wood as well as of horn. The nearly forty references all concern the giving of signals, except some late ones. (e) The straight trumpet was probably always of metal. This is distinctly named over fifteen times, of which some refer to signalling, but in the later histories almost wholly in connection with the Temple ritual. It would seem that this in later times became the characteristic instrument of the priests.

"3. The stringed instruments are decidedly prominent, but their exact form is in doubt. (a) The harp was probably a lyre rather than a true harp, and therefore analogous to the modern Arab instrument. Over thirty-five references imply that this was universally employed in both secular and sacred connections. In two-thirds of these it is associated with the psaltery, in about one-third of them with the cymbals and the drum, and in about the same number with one or the other trumpet. (b) The psaltery was probably not a psaltery, which term properly belongs to one variety of the zither, but either a triangular harp, perhaps resembling the Greek *trigon* (as the early Christian Fathers understood), or, still better, some form of lute and therefore analogous to the common Egyptian *nefer*. In about twenty-five references it is nearly always associated with the harp, which would seem to imply that the two were not of the same class, but complementary. We are absolutely sure from monumental evidence (outside of Palestine) that the Hebrews used a lyre, though that this was actually called *kinnor* cannot be fully demonstrated.

"4. Collective terms for instruments occur in some cases, especially the expression 'implements of song.'



EGYPTIAN MUSICAL INSTRUMENTS

"It is likely that somewhat early in Hebrew history musicians were recognized as a distinct class in the community. Certainly this was true when the official ministrants of the Temple were fully organized. 'Singing men and singing women' are named as if well known, especially as helpers at festivities, probably also as professional mourners. Attached to the Temple, at least in later periods, were singers and players, both men and women, set apart from among the Levites. The Chronicler gives extensive details about their organization and activity. Their first institution is attributed to David, under the advice of Gad and Nathan, and they are said originally to have been divided into Kohathites, Asaphites, and Merarites. The total numbers is given as 288, arranged in twenty-four courses. In the Temple their station was at the east of the brazen altar; they served also on occasion with the army. At the Return the number of Asaphites is given as 128 or 148 and the total as 200 or 245. Provision was then carefully made for their free maintenance, as for the priests and other Levites. As to the actual styles and forms of music used, we are thrown back almost exclusively upon conjecture. We infer that vocal effects were those emphasized, instruments being used only for accompaniment. Song was doubtless in unison, loud and harsh, mostly in rather irregular cantillation or recitative, though sometimes strongly rhythmic, the melodies being based upon modes or scales differing from those of modern European music and very likely provided with manifold melodic embellishments, as in Oriental singing to-day. The parallelism of Hebrew poetry suggests that singing was to some extent antiphonal. From the instruments named, we infer that rude harmony was not impossible: certainly, there must have been crashes of concerted sound. It is a mooted question whether or not the traditional cantillation of modern synagogues sheds any light upon these ancient usages. This is improbable, or, if it does, there are no certain criteria for identifying the ancient material. That vociferous praise was made prominent in Hebrew worship after the Exile is evident; however, so far as we can now see, its historic significance lies, not in what it was artistically, but in the fact that its existence

DANCE OF THE MOROS TO THE MUSIC OF CYMBALS AND HAND DRUMS

THE "MARIMBA" OR AFRICAN PIANO PROVIDED WITH RESONATING GOURDS

and the records of it have afforded a warrant for the free application of music in Christian worship."

The Hebrews and Greeks probably derived much of their knowledge of music from the Egyptians. In the time of King Solomon 4,000 musicians were employed in the temple service. Greek music is customarily divided into three periods —the Mythical Age prior to 675 B.C., the Classical Period 650-338 B.C., and the Alexandrian Period 325 B.C., to the Christian Era. The Greeks were so highly developed that they eschewed loud and blatant instruments of percussion, while string instruments, the lyre and cithara, were very popular and we all know of the Pan's pipes, or mouth organ of seven reeds bound together. The Romans adopted the Greek instruments, but trumpets and brass horns were added.

The secular and religious music of the early church and the music of the Middle Ages would lead us too far from the narrow path blazed out for this brief sketch, but what a fascinating vista is presented—the violin of the "string choir"; the "wood wind choir" with its flute, clarinet, oboe, and bassoon; the "brass choir" with its horns, trombones, cornets and trumpets, the organ, the oratorio and finally that most massive of all productions "Grand Opera."

Music has encircled the globe and we have gathered together a few examples of interesting instruments from widely differing climes.

The worst that has ever been said about the people of ancient Peru recently emanated from the American Museum of Natural History. It has been discovered that they had "jazz" bands. It is even hinted that the Inca host, in the siege of Cuzco, tried to rout Pizarro with the blare of oboes. The said reflection upon the character of the Peruvians is brought to light in a study made by Charles W. Mead, assistant curator of the department of anthropology, of the museum's collection of prehistoric musical instruments. They include bells, cymbals, rattles, pipes, flutes, whistles and an unmistakable ancestor of the oboe. No drums have been found in the old graves, but they were pictured by native artists of the time and described by early writers. "There is still used by a number of tribes in the Amazon region," says the museum's summary of Mr. Mead's findings, "a piece of cane from two to five feet long, with one end closed by some gummy substance, through which is passed a split quill forming a 'reed.' This is, of course, a forebear of the oboe. It was undoubtedly this type of instrument which constituted the 'cornets' said to have been used by the Inca army at the siege of Cuzco. The Incas are credited in Mr. Mead's paper with possessing percussion and wind instruments. They did not know how to make music by the vibration of strings, but really the only thing in their favor is their apparent ignorance of the saxophone.

Cymbals or metallic basins of varying sizes, set in vibration by clashing them together, are very old and were in use by the Assyrians. We find many references to them in the Bible and the modern Egyptians use cymbals that might have been picked off the walls. Turkey is still celebrated for its cymbals which are exported all over the world. Copper gongs and other instruments which stand high as sound producers are in use to-day in every savage and semi-civilized country of the world. One of our illustrations shows a Moro concert in the Philippines where cymbals, gongs and drums are used. The gong needs no description, but the drum is curious, for it is of the "keg" variety, and is beaten with the hand and fingers of one hand, while the other hand wields and beats the drum with sticks.

In Siam we find many interesting musical instruments, particularly the "Phan" or mouth organ, made of bamboo. There are sometimes as many as 14 pipes inserted in a hollow piece of wood and bound together with bamboo shorings. In an example at the Metropolitan Museum of Art, the longest pipe measures 70 inches.

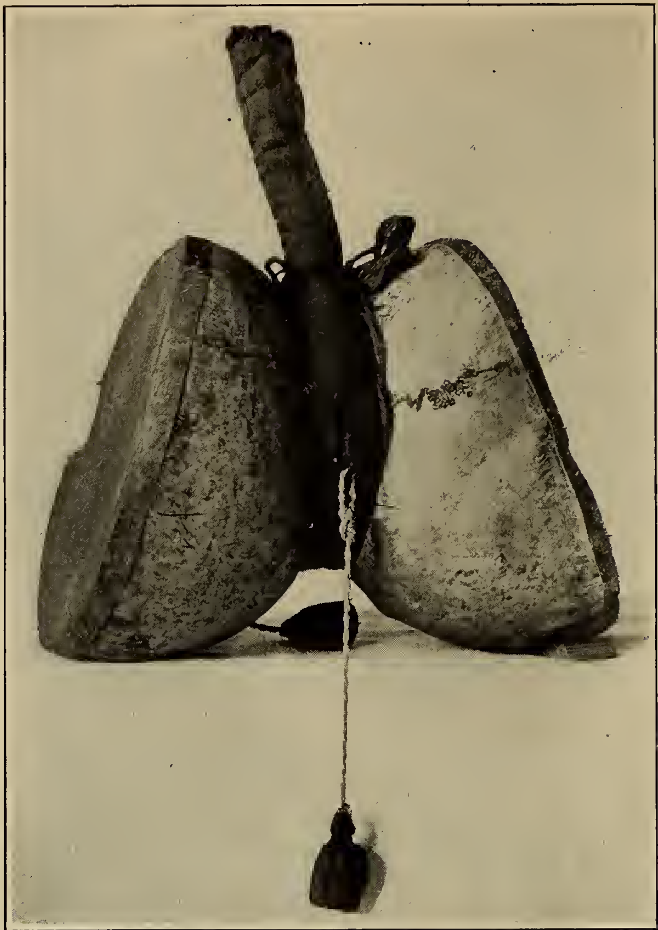
In India the Buddhist priest is a power in the community and the drum used is composed of skins stretched over two gourds or two skulls. Through the courtesy of Miss Frances Morris, Curator of Musical Instruments in the Metropolitan Museum, we are enabled to show a picture of a "Daman," or skull drum, which is 7¼ inches high by 6½ inches wide. The "raw material" for these skull drums is obtained from violators of the seventh commandment. The front part of the skull is cut away and the two skulls are fastened together and the cavities covered with skin, thus forming a drum with two heads. A cord with a bit of wax fastened to the end is attached at the junction of the two skulls and when the instrument is shaken the ball strikes the heads alternately. A bell is used in conjunction with the drum.

The Medicine Man of Siberia finds his drum and bone drumstick invaluable in overawing his native tribesmen. The Shaman's drum usually has a diameter of 27½ inches one way and 22 inches the other, and is 1¾ inches thick. Good examples exist in the American Museum of Natural History and in the Metropolitan Museum of Art.

The "Marimba" is an instrument which exists in many forms in many lands. The group shown in one of our engravings are dispensing music to an audience of Cameroons who have recently changed their allegiance from the Kaiser to France,

owing to circumstances beyond their control. The Marimba has been called the "African Piano" and it is certainly built along scientific lines, even though primitive. The instrument as shown in the photograph is supported by a harness and consists of bamboo slats which are tuned by making them longer or shorter, thicker or thinner. The slats are beaten with a stick of wood covered at the tip with virgin rubber. Under each of the slats is a resonator made of a dried gourd. Sometimes these resonators have a reed in the interior to help the volume of sound. A specimen from Zululand at the Metropolitan Museum has 12 bars, each about 2 feet 8 inches long. In certain districts the Marimba is used only by a special caste. In the catalogues of musical dealers today we find the identical principle used, only the bars are of steel and hard wood and the resonators are of brass.

The entire subject of musical instruments could be investigated indefinitely, but limitations of space prevent us from pursuing the subject further. However, those interested will find ample material for study in the museums cited, and a fascinating study it will prove.



Courtesy, Metropolitan Museum of Art

THIBETAN DRUM OF THE SKULLS OF A MAN AND WOMAN WHO HAD VIOLATED THE SEVENTH COMMANDMENT

ACOUSTIC METHOD OF MEASURING AIR VELOCITIES

THE accurate perception of the direction of sound depends, according to Hombostel and Wertheimer, on the ability of the ear to appreciate the small time interval which elapses between the arrival of a soundwave at the two ears. The perception of directions depends, according to a definite law, on the extent of this time interval. Now if the angle from which the sound is coming be known, it is easy to calculate the time interval, and in this way it has been found that time intervals of 3×10^{-5} sec. give a measurable effect. This method of measuring minute intervals is used by the author for the measurement of the velocity of a stream of gas or of a moving body, as follows: A sound wave is started from a point which is equidistant from two observers. Owing to the velocity of the intervening medium, it reaches them with a short time interval between the two stations. By angle measurement the value of this interval is deduced, and hence the velocity of the medium is found.—W. Kunze, in *Phys. Zeits.*, Aug. 15, 1920. Abstracted through *Science Abstracts*, April 30, 1921.

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THE SHAMAN'S DRUM IS THE SIBERIAN STANDARD OF MUSICAL INSTRUMENTS

THE MOUTH ORGAN OF SIAM. THIS INSTRUMENT MAY HAVE AS MANY AS 14 PIPES

BUDDHIST PRIEST OF INDIA WITH TEMPLE INSTRUMENT, DRUM AND BELL

More About Motion Pictures in Relief*

Another Theory Explaining the Optical Illusion of Projection in Three Dimensions

By Jean Brizon

IN an article recently published in *La Nature* (*a translation of this article appeared in the Scientific American Monthly of June*, 1921, *pages* 531-532.—Editor) Dr. Pech set forth his explanation of the optical sensation of "relief," *i.e.*, of an impression of three dimensions, obtained by him by means of a screen having a curved surface.

I have studied this question extensively for several years and I have obtained results which agree perfectly with the very interesting effects described by Dr. Pech. However, I explain these in an entirely different manner.

I was led to take an entirely different view of the matter by the results of the following experiment:

If two exactly similar positive views on glass, taken from the same negative, are superposed and then examined by transmitted light, the eye will have a tendency to bring forward the first view to the foreground, while relegating the second to the background, thus making a sort of natural selection. This impression is quite unmistakable, of which fact any

FIG. 1. A GRATING PLACED BEFORE THE SCREEN

one can readily convince himself by experiment; the eye receives an impression of depth in spite of the fact that the identical view is represented upon each of the two plates. The same thing holds true and the eye continues to make a selection, even when there is only a portion of the view upon the first plate, while the rest of the view is shown on the second plate. Those parts of the foreground borne by the first plate will attract those portions which are shown upon the second plate, and those portions of the background which are represented on the latter will be sufficient to throw to the rear the entire background, and this will hold good *no matter in what manner the image is distributed between the two plates.*

This result, which is not very interesting from a practical point of view, inspired in me nevertheless a lively hope that it might find an application in cinematography. I, therefore, projected views upon screens composed of several planes and I found that in all cases, no matter what the scene projected upon the screen, the eye at once made a selection so as to bring the first plane forward; in this manner a quite extraordinary sensation of streoscopic relief was obtained, a sensation which increased in intensity the greater the separation of the planes of the screen. The screen can be made in various manners; for example, we can place in front of an ordinary screen, at a certain distance from it, a screen in

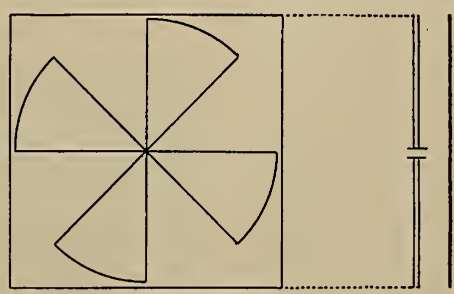
FIG. 2. A CORRUGATED SCREEN

the shape of a grill or grating formed of the elements of the screen (Fig. 1). We can also make use of a single screen having a series of grooves or corrugations as indicated in Fig. 2, which amounts in practice to the same thing as the former. Finally, a very amusing method of producing the screen may consist in making use of the well-known phenomenon of the persistence of vision upon the retina for a certain length of time; this third method enables us to give the spectator a complete and simultaneous view of the image upon several planes with spaces between them. This method consists in placing in front of an ordinary screen one or more portions of screens to which there has been imparted a rotary movement in a plane parallel to the fixed screen; in Fig. 3 a simple solution of this device is shown in which circular sectors are employed for the first screen.

Unfortunately, and the fact is greatly to be regretted, it is necessary in order to observe the screens, to be as far in front of the front screen as the distance between the extreme planes; this is clearly evident for when viewed from the side the image is in fact cut or deformed.

The screen employed by Dr. Pech offers a very happy method of obtaining a screen having several planes, since the edges alone of the screen are raised and this so slightly as not to discommode those spectators seated to one side; this curve has been so calculated, on the contrary, as to compensate at least in part for the error of lateral elongation which is the very one which annoys the spectator seated at one side when a plane screen is employed. This method, therefore, enables us to profit by a slight separation at the edges, in which location are often found the objects situated in the foreground. We thus obtain a slight impression of depth for these objects; unfortunately this impression can be proportional merely to the amount of the separation at the margins which is limited in practice.

I hope that Dr. Pech will not bear me a grudge since my object in saying this is purely scientific—but I am unable to



SIG. 3. THE ROTATING SCREEN

believe that the phenomenon of the distortion of the image upon the retina upon which he bases his theory, plays any part whatever in the case of the present screen. To my mind the proof of this is to be found in the mere fact that the same impression of depth or relief may exist at any rate so far as the spectator seated in the center is concerned, with a screen composed of hollows and protuberances arranged at random.

Besides, the well-known fact which Dr. Pech employs as the basis of his theory, namely, that a photograph observed either under a magnifying glass or from a very short distance, makes an impression of relief upon the eye, is in my opinion, due simply to the circumstance that in both cases the observer unconsciously assumes his eye to be in the same position as the lens by which the photograph was made, *i.e.*, subject to the conditions which are involved in perspective. In most cases, indeed, we always look at a photograph from a distance much greater than that of the focal length of the lens used in making the picture. But it is only in case one transports oneself in fancy into the same conditions as those under which the picture was taken, *i.e.*, when the eye represents the original lens, that one is able to observe the scene in its natural proportions; in other words, this is possible only when the relative magnitude of the planes is preserved.

In support of this theory I may state that I have made the observation that, so far as moving pictures are concerned,

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), April 16, 1921.

the most definite impression of reality is obtained, when the ordinary screen is employed, by a spectator seated in the center of the room. The lens commonly used for taking pictures is, in fact, one having a focal length of 50 mm., and the degree of enlargement, which varies of course, according to the size of the room where the pictures are shown, is about 300 diam. for a 30 m. room. Hence those spectators seated at a distance corresponding to 300 x 0.05—*i.e.*, 15m. from the screen, are ideally placed to obtain the best results. Furthermore, attention may be called to the fact that when the spectator is too far off from the screen—*e.g.*, at the end of a very large room, the picture on the screen will look as if it were a painting.

The foregoing considerations appear to my mind to support a theory which may be stated as follows: The brain of man seeks always to recover the natural vision of the eye in the artificial images presented to it, and the sort of screen now in question merely lends its aid to this tendency.

In conclusion I may say that I believe it will not be very long before a method will be found—whether by making use of the principles I have just stated, or by means of others, of which it may be easier to make a practical application—to produce a true, but nonbinocular, impression of relief in moving pictures.

CURIOUS FACTS ABOUT EYES

In the predecessors of the human race the eyes had a lateral position just as they still do in the human embryo. In the second month of embryonic life the eyes are still placed at the side and are slanting just as they still are in many dogs and cats; moreover, the eyes and nostrils of the embryo are still quite close together. The position of the eye is quite remarkable. In embryos from 2 to 5 months old are found all stages of the mutual coming near each other of the eyes, a deep furrow being formed above the nose which is still pressed somewhat downward. The forward direction in the position of the eyes is a great advantage. Animals with their eyes placed at the side of their heads find themselves awkwardly situated in regard to many objects. Sometimes it is very confusing to them to perceive a different image with each eye. This often makes it impossible for the animal to determine whether an object which seems large is actually large in fact or only appears so because of being so near, since when the eyes are placed at the side they lack the stereoscopic power of vision with the corresponding ability to judge correctly of magnitude and distance. Such vision is conceivable only when the visual axes of the eye are placed parallel to each other, when their voluntary steadiness of gaze is directed toward the same point. But the parallel position of the eye socket is not alone sufficient to procure parallel vision. In small children we see the eye wandering restlessly and aimlessly about as if they were seeking something. They do not arrive at a parallel placing of the visual axes until they are several months old, after constant practice.

The animals with eyes placed at the sides of the head do not possess a bony partition between the eye sockets and the space behind these which contains the muscles required in mastication. The boundary is formed by a thin layer of connective tissue. The narrowing of the nostrils through the frontal position and the approach toward each other of the eye sockets affects the organ of smell disadvantageously, and this is still truer in most apes, whose sense of smell is very feeble. The opinion was formerly held that the distance between the inner corners of the eyes varies considerably in various races of men, but this is not correct. There is but slight difference in this respect as regards different races; on the other hand, this feature varies widely among individuals within the same race. There are, however, fairly marked differences of race shown with respect to the form of the bony entrance to the eye socket. This is very long in Mongolians, Indians and Esquimaux while the smallest difference between the height and width of the eye socket is found in the nearly related Australian blacks, Tasmanians, and New Caledonians, as likewise in the Tierra del Fuegans in the extreme south of South America.

In all races the width of the eye socket is markedly greater in men than in women, but the difference is not so marked as respects the height of the eye socket, since this is but little greater in men than in women. In all branches of mankind the eye of the woman is less long than that of the man and another difference between the two consists in the fact that the female eye socket is much greater with respect to the magnitude of vision that is that of the male. It appears to be the fact that short-sightedness is much more commonly found where the entrance to the eye socket is long than where it is short. It is a very striking circumstance also that the breadth of the eye socket is in direct proportion to the shortness of the head. —Translated for the *Scientific American Monthly* from *Naturwissenschaftliche Umschau d. Chem.-Zt.* (Berlin) for Feb., 1921.

NEW MICROSCOPE FOR STUDYING OPAQUE CRYSTALS

VERY small opaque crystals are very hard to examine by present methods. The ordinary microscope, which is meant for use by transmitted light enables the operator to see merely their contour in case they are single and only a rather shapeless general contour when they form groups or clusters as is very frequently the case. For this reason some investigators prefer to make use merely of a very strong magnifying glass of sufficient power to reveal gleaming points from which they conclude that the body is crystalline in nature, although the form of the crystals cannot be seen in case they are very small. A great many devices have been proposed for examining and photographing opaque bodies and thin sections of alloys; it has remained, however, for a French inevntor, M. Maurice François, to suggest an improved method of examining opaque crystals. This was presented before the French Academy of Sciences at their session on April 18, 1921, but since it is too long for these pages we present merely a résumé of it, taken from *Le Génie Civil*, April 30, 1921:

M. François's process of observation makes it possible to perceive distinctly every facet and all the details of the crystals. It consists in observing by reflection crystals placed above an *opaque spot* and having their upper portion strongly illuminated by a very small concave mirror which is screwed to the lower portion of the objective, and which is pierced at its center by a circular aperture about 1 mm. in diameter.

In its complete form the system comprises three special parts, the concave mirror, the opaque spot, and the illumination which is situated in the axis of the microscope beneath the screw plate.

EFFECT OF HEAT ON CLAYS, KAOLINS AND BAUXITES

THE results of some interesting experiments with various clays made by the French chemist, A. Bigot, were recently laid before the French Academy of Sciences (Session of April 4, 1921). The experimenter found upon heating specimens of clay, kaolin, etc., to temperatures at which they soften, become deformed, and sag under their weight (these temperatures being regarded as practically fusion points), that the following laws obtain:

1. Bauxite, kaolins and clays which contain no free silica begin to contract below 1,000 deg. cent.
2. Any specimen of clay or bauxite which swells at a point below 1,000 deg. cent. contains free silica.
3. Clays and kaolins heated rapidly swell up before reaching the point of fusion. Bauxites do not exhibit such a swelling. This inflation is due to the volatilization of the silica or silicates, or of other acids or mineral salts which are set free at the instant when the substance becomes softened and vitrified; in the act of volatilizing, these elements form vesicles imprisoned in the mass, causing the latter to swell by the pressure they exert.

GENERAL VIEW OF THE POT FURNACE AND WORKING SPACE IN A PLANT DEVOTED TO THE HAND BLOWING OF GLASS LIGHTING FIXTURES, ETC.

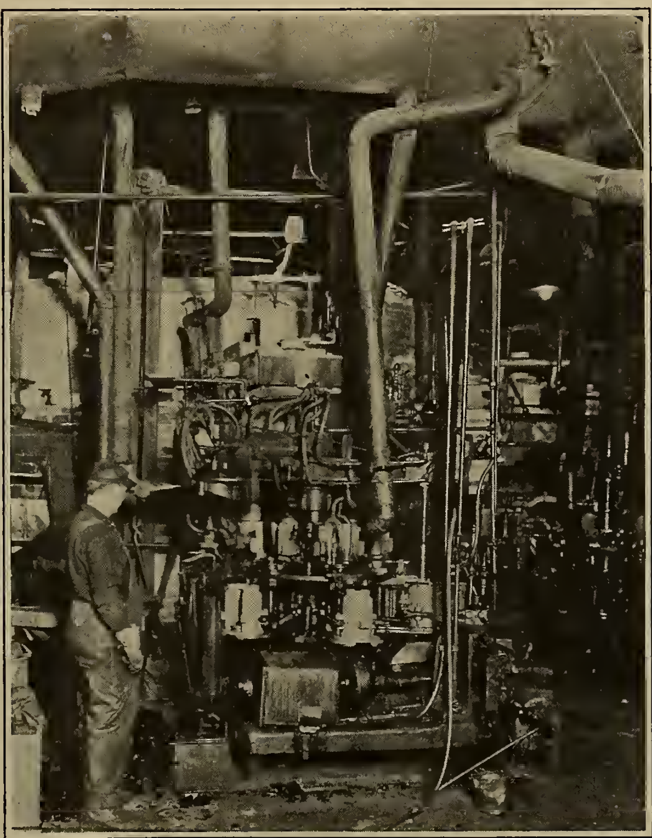
The American Glass Industry

Machinery Employed in Making Bottles, Window-Glass and Plate Glass

By Robert G. Skerrett

WHO has not wondered how glass is made? All of us are familiar with it, in one form or another, by daily contact, but not many of us know anything about the basic industry that has been a help to us for scores and scores of years. Indeed, it is doubtful if the laity at large has more than a hazy notion of the magnitude of this diversified trade which absorbs the attention of an army of 79,000 workers and executives.

According to the most recent authoritative figures available, the value of the glass commodities produced in this country in 1914 totaled $123,085,019.00; and at that time we had invested in the business capital aggregating $153,925,876.00. What is even more suggestive, perhaps, during the decade ending with 1914, the capital in the glass industry increased 72.2 per cent, and the value of the wares grew by nearly 55 per cent. The great bulk of these products supplied a domestic demand, and this fact illustrates how big a part glass plays in America's material life. While data are not at hand covering the entire industry for the past six years, still the manufacture of glass has expanded tremendously the while; and because of our enforced dependence upon our own resources during the World War, we have not only amplified our plant capacities, but we have proved that we can make various types of glass which previously we bought abroad.



A BOTTLE-MAKING MACHINE

The molds are mounted on two revolving tables—one above the other. On the upper table are the bottle blank molds in which the plastic glass is first formed, bottomside up, and then automatically turned over and delivered into larger molds on the table below where the bottles are blown and finished. The tank at the rear supplies molten glass in just the right quantity to the blank-forming molds as they revolve

The story of glass making in this country dates back to the beginning of the 17th century, and the records show that the English colonists erected a plant at Jamestown, Virginia, along about 1609. Those pioneers probably concerned themselves with the blowing of bottles. Twelve years later, a group of Italian craftsmen were induced to sail for Virginia, and their cunning was devoted to the fabrication of beads so much desired as a bartering medium in the settlers' dealings with the Indians. Gradually, the manufacture of glass of divers sorts was taken up by other of the American Colonies, and, as might be expected, interest for the most part was centered in providing bottles and window glass, needed alike by rich and poor.

For decades glass making in this country was confined to the settlements along the Atlantic coast, where was to be found sand in plenty, lime from oyster shells, potash from wood ashes, and an abundance of fuel in the prevalent stands of aboriginal timber. It was not until 1796 that coal was used to develop the necessary fusing or melt-

ing heat, and the first plant marking this departure was built at Pittsburgh. Generally speaking, the matter of fuel has since become one of the principal factors in determining where to undertake the manufacture of glass. This is not hard to understand when we recognize that the cost of fuel is, exclusive of labor, usually the largest single expense involved in the production of this commodity.

In the early days, wood and coal were severally employed for direct firing until Siemens, in Germany, brought out his regenerative glass furnace in 1861. He showed how it was possible to generate gas from the coal outside of the furnace and then burn it, on the principle of the Bunsen burner, in melting the glass ingredients held in clay pots. The gaseous fuel was more economical, reduced the melting time, and made it practicable to improve the quality of the glass while augmenting the output. As might be expected, the advent of natural gas and the use of fuel oil have influenced the industry and done much to stimulate the shifting of the plants to those points where these fuels could be had readily and at comparatively low prices.

The idea of the regenerative furnace has been developed greatly since Siemens called it into being, and most of the furnaces installed to-day are of the so-called tank type which melt the glass in large quantities without recourse to pots; and they are so constructed that the glass, during its melting, undergoes automatically a purifying process. These furnaces run continuously for months at a time; they furnish glass of a superior quality, and they maintain a steady supply of many tons of the fluid, incandescent, vitreous matter.

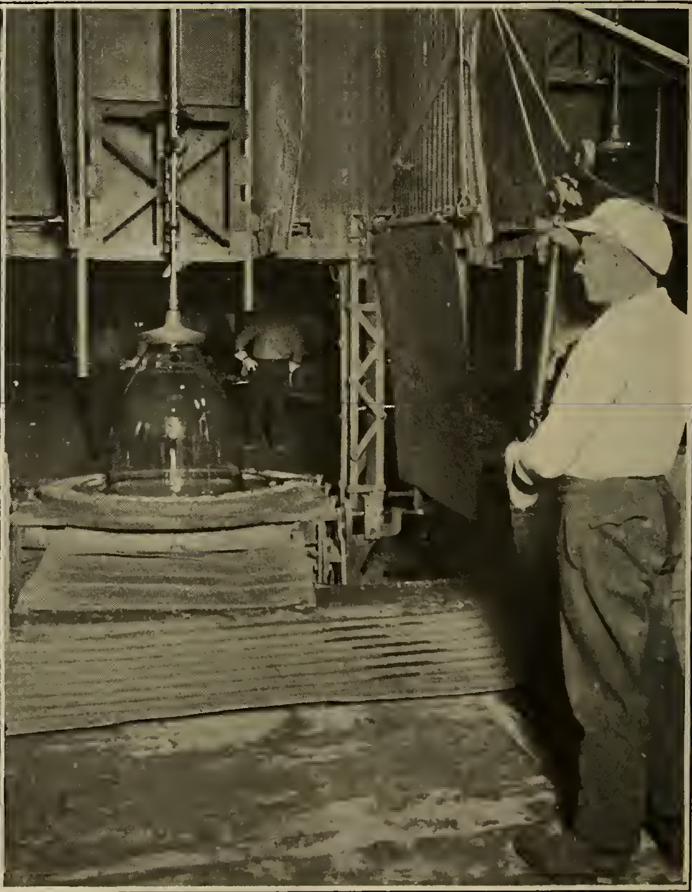
In the past, the glass blower was an indispensable worker, and even to-day he continues to retain his place in the craft, but in diminishing numbers. The tendency now is to substitute machinery for manual labor wherever conditions warrant, and this movement is the consequence of the prime charge which wages represent in the total cost of manufacturing glass. It would be quite out of the question for us to have all of the bottles, jars, tumblers, etc., that we can now buy at a moderate price if inventive cunning had not called into being apparatus that require a minimum of human supervision. Some of these machines are semi-automatic and need the services of one or two men, while the most recent are entirely automatic and a single man can look after a group of them—his duty being merely to oil them or to remove a defective mold and substitute a new one.

By means of exquisitely synchronized equipment, gobs of white-hot plastic glass are fed mechanically from the melting tank and sent scurrying down metal chutes into the molds of one, two, three, and more automatic machines, where the glass is successively formed into bottle blanks, for instance, and then delivered, without human aid, into the blowing molds where the bottles are finished. These apparatus are capable of turning out containers ranging all the way from 1-dram vials to 12-gallon bottles. The vials are produced at the rate of 165 a minute, and the bulky siphons are modeled at a speed varying from 10 to 14 a minute. The machines do this right along twenty-four hours a day for six days a week.

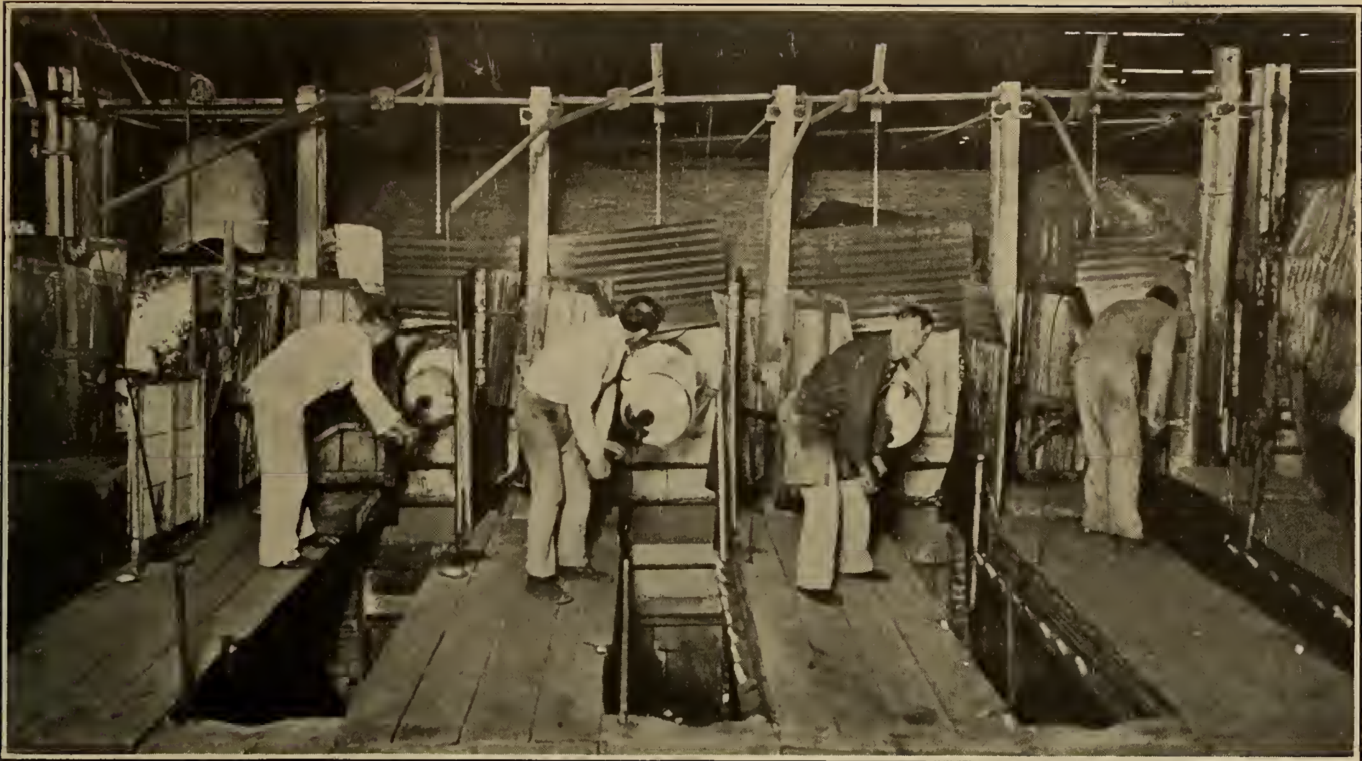
Instead of the lungs of the glass blower, motive energy is furnished in the form of compressed air, which is peculiarly fitted, because of its "cushioning effect," to do the pressing and blowing, to regulate the glass supply, and to cool the glass at certain stages. Further, compressed air tends to moderate the atmosphere where the men work, to give the necessary impulse to the gaseous fuel at the tanks, and to perform various other essential services. In the tumbler machines, air actuates the formative plungers and seals the molds so that the lump of glass can be confined and pressed into shape. As the newly-made tumbler issues from the mold it passes across the path of a stream of cooling air, and this makes the glowing vessel firm enough to hold its shape when lifted by pneumatically-operated tongs and swung onto a near-by rack or a metallic conveyor which transports it to the lehr or annealing oven.

In 1914 our output of bottles, jars, and similar commodities

HAND BLOWER MAKING SHADES FOR ELECTRIC LIGHT FIXTURES



BLOWING WINDOW GLASS CYLINDERS BY COMPRESSED AIR



ONE SIDE OF A FURNACE WHERE CYLINDERS OF WINDOW GLASS ARE BLOWN BY HAND

The operatives are about to withdraw the partly formed cylinders from the furnace and to elongate them by swinging them in the adjacent pits or swing holes

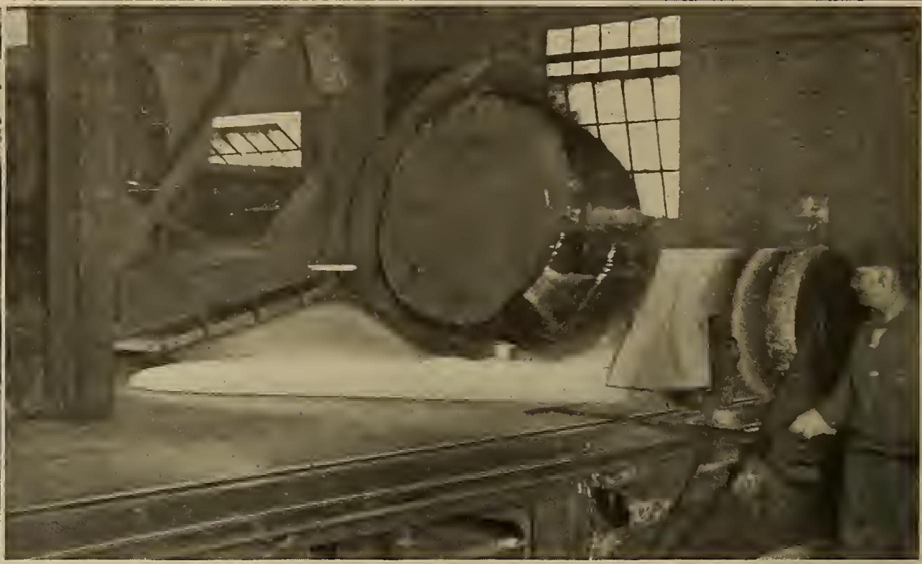
was valued at $51,958,728; and this branch of the business represented something over 42 per cent of the value of the total glass production that year. The bottles, jars, vials, etc., manufactured in the United States four years ago aggregated 5,000,000,000. In 1900 our factories made only 1,121,000,000; and for years our export business was of moderate proportions. Three years back we exported containers to the value of $2,781,076, and during 1919 we sent to foreign markets wares of this kind worth $5,283,655.

The machine-made commodity is superior to the hand-blown bottle because it is of uniform finish and of standard weight and capacity. The latter element is important inasmuch as it makes it possible, in turn, for the purchaser to employ automatic-filling apparatus—thus speeding up packing or charging. It is estimated that one automatic machine, capable of an output of 350 gross of beer bottles, for example, in twenty-four hours, takes the place of 54 skilled workmen; and an automatic feeder will deliver enough glass directly from the tank to the machines, where the commodity is milk bottles, to dispense with the services of 13 highly-trained operatives.

Without entering upon the niceties of the subject, it should be evident that in dealing with a material like glass it is necessary to handle it at every stage more or less carefully, and this is particularly so during the interval when it passes from the molten, viscous state to that of initial fixedness of form. It is indispensable that the glass be of just the right temperature when it leaves the furnace, and it must be given its impressed or blown shape while still plastic. Similarly, when it has been modeled and then "set" by a breath of air, no time should be lost in transferring it to the lehr. According to the article's condition when it goes into the annealing oven, more or less heat is required to bring it up to the desired temperature, so that the gradual cooling thereafter will cover a sufficient range to insure proper annealing. It is practicable to economize in fuel and to shorten the annealing period by a close co-ordination of the operations that take place between the machines and the lehrs, and thus to effect a saving of many thousands of dollars annually.

SHOVING A "ROLLER" OF WINDOW GLASS INTO A FURNACE FOR THE PURPOSE OF FLATTENING IT INTO A SHEET

In the building-glass department of the industry the manufacture of window glass dominates, representing about 48 per cent of the business. Building glass, by the way, includes plate glass, wire glass, and obscured glass, *i.e.*, the material so often used for office partitions, doors, skylights, transoms, etc. During 1914, our plants produced 400,998,893 square feet of window glass, or more than 8,000,000 boxes, each containing 50 square feet, and having a value of $17,500,000. At that time, well-nigh all of it was for domestic consumption, and we sent abroad only about 1.8 per cent of the output. In 1917, however, we exported $3,483,596 worth of window glass, and we manufactured



(*LEFT*) A POT OF MOLTEN GLASS BEING REMOVED FROM THE MELTING FURNACE AND (*RIGHT*) POURED OUT UPON AN IRON TABLE TO FORM A SHEET OF PLATE GLASS

9,000,000 fifty-foot boxes of the commodity. We could not have done this but for the machine processes which we have developed.

Approximately 60 per cent of all window glass made in the United States is of machine origin, and the 40 per cent remaining is hand blown. The difference between the two procedures starts after the glass is melted in any of the improved types of the tank furnace. However, the machines commonly use a softer glass, which is easier for them to deal with while they are forming cylinders or "rollers," which are much longer and larger than those possible where hand blowing is relied upon. In order that the layman may appreciate these competing industrial methods, it might be well to describe briefly how the hand blower does his work.

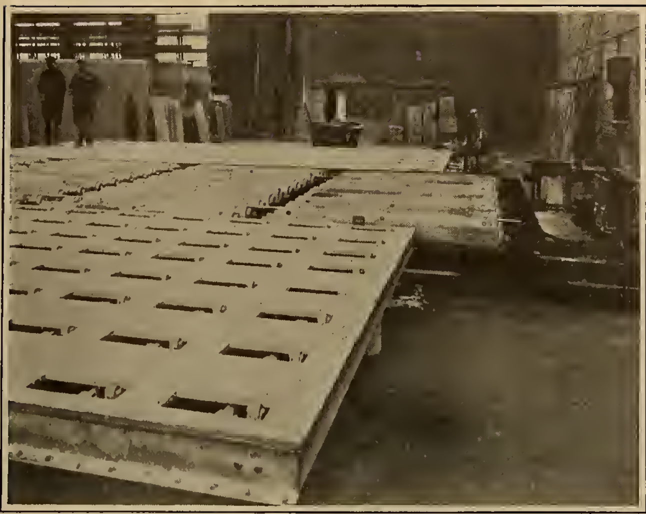
At a hand plant, cylinders are blown varying from 12 to 16 inches in diameter and 5 feet long, or they may be from 16 to 20 inches in diameter and 7½ feet long. A "shop," *i.e.*, a group of associated operatives, consists of three men—a gatherer, a snapper, and a blower. There are, besides, flatteners and cutters.

The gatherer puts his pipe into the tank and works it around to accumulate a lump of plastic glass of sufficient bulk. To do this he may go to the tank four or five times, and when he has the quantity desired for the blowing of a cylinder, then the snapper carries the pipe with its glowing load to the blower. The blower first manipulates the glass on an iron block to shape it properly on the neck of his pipe, and by the time this is done the glass has become too rigid to blow. Therefore, he takes it back to the furnace, reheats it, and then proceeds to blow and to stretch it out into a cylinder by swinging the mass back and forth in the swing hole alongside and beneath his platform. The cylinder is really modeled through the dual agencies of the blower's expanding breath, confined in the cylinder, and the glass's own weight.

THE CASTING TABLE OR "SLAB" OF A PLATE GLASS PLANT

After the glass has been poured upon the table the roller is moved from end to end to iron out the glass into a large sheet of uniform thickness

When the blower has finished his task, the snapper squares each end of the cylinder and splits it lengthwise on one side. Thereafter the glass is put in a furnace and pressed flat on "stones" of fire clay, and from this furnace it passes on through an annealing oven. Finally, it is cut into commercial sizes by the cutters, packed, and shipped broadcast. The hand window-glass blower produces an average of nine cylinders an hour, and his working week is one of forty hours. As a rule, he is not employed more than seven months a year; and the heat in which he labors is, broadly, the most debilitating factor with which he has to contend.



CUTTING TABLES IN A PLATE GLASS FACTORY

These tables are located at the exit of a lehr and are arranged with rollers to facilitate the sliding of the glass. The tables can be tilted so that the big sheets of glass can be caught on one edge and lifted off for stacking by means of a traveling crane.

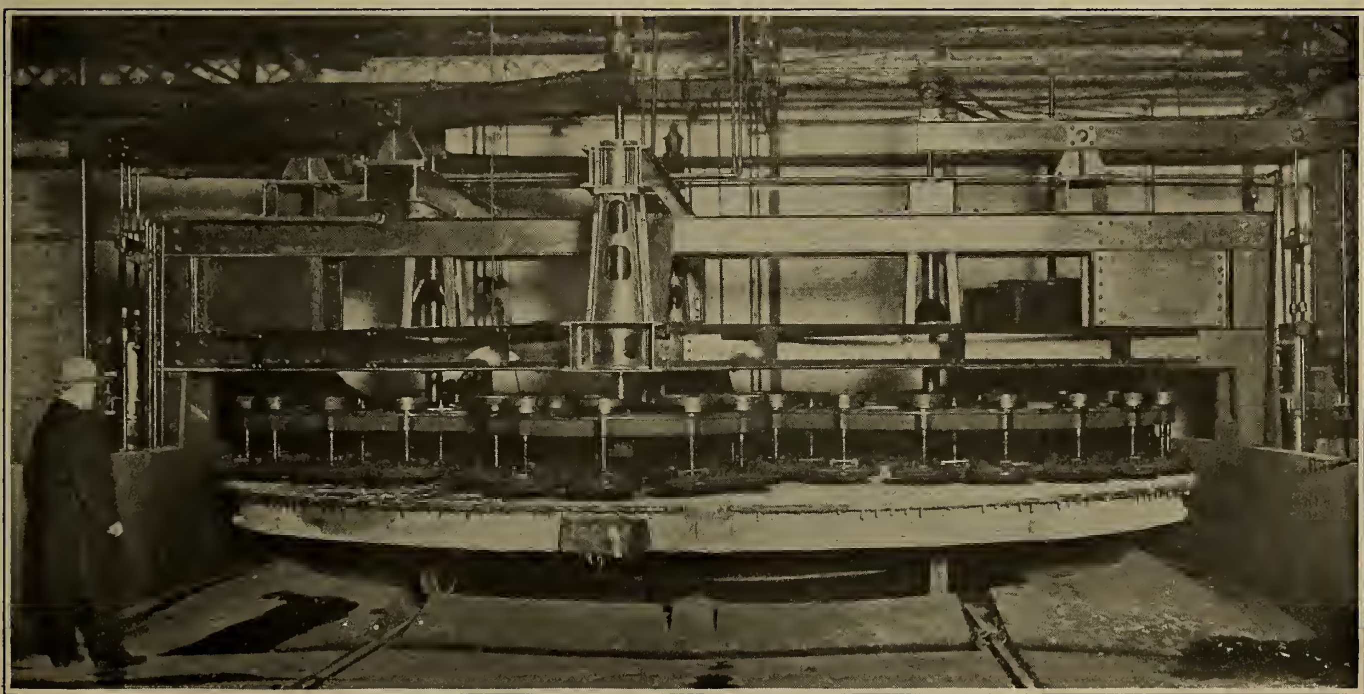
After prolonged experimenting, apparatus were brought out about 1902 that were capable of blowing successfully cylinders of window glass. Since then much has been done to improve these machines; and with them it is entirely practicable to blow cylinders from 20 to 30 inches in diameter and from 25 to 35 feet in length. That is to say, from a single cylinder so fashioned it is possible to obtain quite eight times as much glass as that yielded by a cylinder of the hand-blown sort. Not only that, but the large machine cylinder is formed faster. The blowing air is supplied by compressors, and a single operator can control simultaneously the functioning of from three to five machines.

In place of the hand-blower's pipe, the machine is equipped with a pipe terminating in a mushroom-shaped cup. This is mounted upon an electrically-operated hoist and guided so that it will move vertically without horizontal motion. This pipe is called a "bait," and is lowered either into a fire-clay pot, which is filled from the furnace, or into a projecting basin communicating directly with the great melting tank. In either case, the bait, as it is drawn out and upward, carries with it at the start a semi-globular bubble of glass which is linked with the surface of the molten mass. As the bait rises it pulls steadily after it a lengthening and solidifying cylinder of glass, and at the same time compressed air is fed into the growing cylinder to keep it expanded and to neutralize any collapsing force of the outlying atmosphere.

The problem of the hoist man is to regulate the vertical speed of the upbuilding cylinders and to control the while the distending charge of compressed air. There are attendants that look after the condition of the molten glass and that fill the pots where it is the practice not to get the glass right from the furnace. Again, there are other operatives whose duty it is to correct defects in the forming cylinders which, if not dealt with promptly, might cause the cylinders to burst and to occasion a loss of valuable material. One has to see these machines at work to realize the ingenuity that has been devoted to their development. It seems a violation of natural laws for the molten glass to flow upward as the cylinder rises out of the bath, but this apparent paradox is due to the viscous nature of the glass and to the quickness with which it "sets" when its temperature falls below the melting point.

But there is still another and later method by which window glass can be made by machine. This process draws a continuous sheet of glass, and does not make cylinders which have to be split and flattened.

The sheet-drawing system requires even less labor than that for the mechanical blowing of long cylinders, and is the outcome of an invention originating about thirteen years ago. Many technical difficulties had to be overcome, and one by one



THE POLISHING MACHINE OF A PLATE GLASS PLANT

The circular table is mounted upon trucks so that the glass can be carried first under the grinding machine and then to the polisher

REMOVING A SHEET OF PLATE GLASS FROM THE POLISHING TABLE

these have been mastered until it is practicable to draw continuously a sheet of glass 200 feet long and 5 feet wide. Depending upon the thickness of the glass the sheet grows at the rate of from 2 feet to 8 feet in length each minute, and the thickness of the sheet can be varied from 1/24-inch to ¼ inch.

To start the formation of a sheet, an iron bar, the bait, about 5 feet long, is lowered, in a horizontal position, into the tank basin filled with molten glass. Next, the bait is lifted and it pulls up with it a clinging strip of plastic, glowing glass. After ascending for a distance of 2½ feet, the bait passes over a roll and travels horizontally, at right angles, to its former course, drawing the lengthening sheet of glass after it and into the contiguous lehr. Just before entering the lehr, however, the glass moves along on a flattening table; and when the bait has cleared this feature of the installation, it is broken off and hoisted out through the top of the oven, while the glass remaining in the annealing furnace is gripped and carried forward mechanically by a series of power-driven rollers. After a run of 200 feet, the glass reaches the cutting table, at the far end of the lehr, and there is subdivided into sheets 208 inches long. These are afterward cut into various commercial sizes.

In the manufacture of plate glass, the molten material, in big pots, is removed from the melting furnace and poured out upon great iron tables edged by a frame of a height suitable to the thickness of the sheet to be cast. Immediately after the glass is teemed from the pot, a heavy roller, which spans the table, flattens out the glass and presses it into the desired form and thickness. The sheet so made, when sufficiently rigid, is lifted and shifted laterally and then shoved into the first of a series of annealing chambers. When it has passed successively through these several compartments —with their lowering temperatures, the annealed sheet issues upon a tilting table, actuated by compressed air, where the glass is cut into large sheets. At this stage the surfaces of the glass are rough. The next step is to polish them.

The polishing tables are big revolving metal discs upon which a number of sheets of glass are secured by a binder of cement. Supported by a framework above each table are numerous smaller discs or pads, and these are mounted so that they can be brought into contact with the glass. In the first operation the pads grind away the roughened upper surface of the glass—sand and emery being consecutively used for the purpose. With the grinding done, the table, which is equipped with trucks, is wheeled beneath a polishing machine, where the pads rub the upturned surface with rouge. The two treatments consume something like three hours. With this work completed, the sheets of glass are reversed, so that the nether rough faces may be ground down and polished. When the glass is finished the sheet is only about half as thick as it was originally. In 1914 we produced more than 60,000,000 square feet of polished plate glass which was valued at nearly $15,000,000, while in 1917 the output reached 75,000,000 square feet.

Mention has already been made of those departments of

TINTING ELECTRIC LIGHT SHADES BY MEANS OF THE AIR BRUSH

the blown and pressed glassware industry having to do with the machine production of bottles, jars, tumblers, etc. The finer commodities, however, are hand blown, and such is the case in the making of lighting goods, pitchers, goblets, vases, and divers other articles. In the so-called "off-hand process," where the craftsman does his own blowing, the glass worker gathers a small ball of glass on the end of his pipe by dipping it in the molten mass and then quickly rotating and withdrawing it. He then rolls his "gather" on a polished iron plate, causing it to assume a cylindrical shape. Then, by a combination of blowing and swinging, the glass bubble is elongated and distended, after which it is put into a hinged mold. With the mold closed, the artisan continues to blow so as to force the plastic glass outward and well into every part of the mold, and in that way he gives it the desired form.

FINISHING UP A HAND-BLOWN PITCHER
The worker is engaged in attaching and modeling the handle from a lump of red-hot plastic glass

When the ware is to have a high polish, and it is so modeled that the glass body can be rotated within the mold while still incandescent, what is known as the pasting process is employed. That is to say, the inner surface of the mold is covered with a layer of paste and dusted with fine charcoal or powdered cork. A glass blank blown in the mold serves to carbonize the paste; and this graphitic deposit thereafter, in contact with the rotated and forming article, imparts to the latter a characteristically brilliant finish. In the making of vases, pitchers, wine glasses and goblets much work is done upon them after they come from the press or the primary mold, and the artisans show a great deal of skill and cunning in the execution of these concluding touches. Inasmuch as the glass chills and solidifies quickly, the commodity in the making has to be reheated one or more times. This is done in a small furnace located near by and popularly known as the "glory hole."

The production of pressed and blown ware, which includes a wide variety of articles, was valued in 1914 at $30,280,000. The output was an increase of substantially 38 per cent over that of 1904, and represented well-nigh 25 per cent of all kinds of glass manufactured seven years ago. It is not possible to say just how much blown and pressed ware we turned out in 1917, but in the course of three years our exports grew from $2,671,000 to $5,412,000 in worth.

In the matter of optical glass we have made ourselves independent of Europe, and today American glass of well-nigh every kind equals the best of the competing foreign products.

THE PRIMARY STAGE IN THE HAND BLOWING OF A PITCHER
The bowl has been formed and is about to be broken off from the blow pipe so that it may be reheated to facilitate the modeling of the spout

PROCEDURE CHART FOR THE REMOVAL OF STAINS FROM WASH GOODS

KIND OF STAIN	COTTON	LINEN	WOOL	SILK	COLORED GARMENTS
ALBUMIN.	Removed in the standard washing process.				The methods recommended for white goods are equally effective for colored goods, PROVIDED THAT THE REAGENTS USED HAVE NO EFFECT ON THE COLOR OF THE MATERIAL. Tests should always be made on some hidden portion of the garment before the reagent is applied to the stain. Begin with the simplest method and work up to the more complex and drastic procedures.
BLOOD.	Removed in the standard washing process. The stain of the hemoglobin will be removed in the bleach bath.		Removed in the standard washing process. The stain of hemoglobin may be removed with hydrogen dioxide solution.		
BLUEING: ULTRAMARINE.	Removed in the standard washing process. If this does not remove all of the spots and specks, treatment with "sour" will decompose them.				
PRUSSIAN.	Before coming into contact with an alkali, these stains will wash out in clear water. If contact with an alkali has changed the spots to ferric oxide (iron rust), a mixture of acetic and oxalic acids (see Chart No. 1, "L. N. A. Standard Formulas") must be used.				
ANILINE.	Many of the aniline blue stains will be removed by the standard washing process that includes a bleach bath. Stains that do not respond to this treatment will be removed by a reducing solution of sodium bisulfite and zinc dust.		Wool and silk should not be blued with aniline blues, because aniline colors dye these fibers directly. In case this type of blue has been used, the stain may be treated with a permanganate solution or with sodium bisulfite and zinc.		
COCOA AND CHOCOLATE.	Removed in the standard washing process.				
COFFEE.	Removed in the standard washing process.				
CREAM AND ICE CREAM.	Removed in the standard washing process.				
DYE: "BLEEDING" OF MULTICOLORED FABRICS.	Where a multicolored fabric (a stripe or plaid) has bled or run, and the white portion has become colored, it is sometimes possible to remove the stain from the white without affecting the color of the original pattern. Small samples of the material should be tried with javelle water, followed by oxalic acid; permanganate solution followed by oxalic acid or sodium bisulfite; or sodium bisulfite and zinc. The best method can be used on the garment.		In the case of wool and silk, the same methods that are recommended for cotton and linen may be tried, using permanganate solution followed by sodium bisulfite, and sodium bisulfite and zinc. Bleach should never be used on these fibers, but hydrogen dioxide may be substituted for it. Efforts to remedy this condition on wool and silk are not apt to be as successful as on cotton and linen.		
"BLEEDING" OF ONE COLORED GARMENT IN A LOAD OF WHITE GARMENTS.	Where a load of white goods has become colored by the bleeding of a ribbon or similar piece of colored fabric, the treatment is the same as given above, with the addition of caustic soda solution for cotton and linen. The success of the treatment is more assured in this case, however. It is advised that a small, inexpensive garment be taken for purposes of determining the best method.				
HAT DYE.	Soak in 95 per cent. ethyl alcohol, rinse in a clean portion of alcohol and launder as usual. Slight stains remaining after this treatment may be treated as directed above.				
EGG.	Removed in the standard washing process.				
FRUIT.	Removed in the standard washing process.		Try the following in order: Warm water, oxalic acid, acetic acid, potassium permanganate solution followed by oxalic acid or sodium bisulfite, hydrogen dioxide and sodium perborate.		
GRASS.	Removed in the standard washing process. If any traces remain they may be removed by treatment with javelle water.		Treat with a mixture of equal parts by volume of 95 per cent. ethyl alcohol and ethyl ether.		
GREASE.	Grease stains are usually removed in the standard washing process. If an exceedingly resistant stain is encountered, it may be softened with a mixture of lard and oleic acid (2 parts of oleic acid to 98 parts of lard, by weight) and washed again. When the oleic acid comes in contact with the soda ash in the usual bath, soap is formed, and being in such intimate association with the grease removes it readily.		Stains surviving the regular laundry process must be treated with an excess of soap by hand or with one of the organic solvents, such as gasoline, carbon tetrachloride, chloroform or ethyl ether.		
GUM OR RESIN.	Use the following solvents: Turpentine, benzene, carbon tetrachloride, chloroform, 95 per cent. ethyl alcohol, ethyl ether, kerosene, gasoline, carbon disulfide. The specific solvent must be determined by test, since the solubility of different gums and resins varies. The solvent for common chewing gum, or chicle, is carbon tetrachloride.				
INK: IRON, ORDINARY WRITING.	Treat with warm acetic-oxalic acid mixture (see Chart No. 1, "L. N. A. Standard Formulas").				
ANILINE.	See DYES and BLUEING (ANILINE) for the ordinary writing fluids. No remedy that is harmless to the fabric is known for the black aniline marking ink used in the laundry.				
INDIA.	Removed in the standard washing process. The stain may be loosened by greasing it with lard previous to laundering.				
BLACK PRINTING.	See INDIA INK.				
SILVER NITRATE.	Soak in sodium thiosulfate solution until the stain disappears, or treat with javelle water till stain disappears, then soak in a weak solution of ammonia to remove the silver chloride formed. (If this precaution is omitted the stain will reappear.)		Treat the stain with potassium cyanide solution. (POISON!)		
INDELIBLE PENCIL.	Removed in the standard washing process. Any traces that remain may be removed with javelle water or with potassium permanganate solution, followed by oxalic acid.		Remove the dye with 95 per cent. ethyl alcohol or potassium permanganate followed by oxalic acid. The mineral matter will wash out.		
IRON.	See INKS (IRON).				
LEATHER.	Light stains are removed in the standard washing process. Deeper stains may be treated with javelle water.		No remedy is known which is harmless to the fabric.		
MACHINE OIL.	The oily stain may be removed after the manner described under GREASE. If the stain is caused by a bearing grease, it may contain some iron or other metal, which, however, can usually be removed with the solution used for INKS (IRON).				
MEDICINE: ORGANIC.	Removed in the standard washing process. A very heavy stain may have to be treated with javelle water.		Stains not removed in the standard washing process must be treated with permanganate solution, followed by oxalic acid or sodium bisulfite solution.		
CONTAINING SALTS OF THE HEAVY METALS, LIKE IRON, SILVER, ETC.	Iron stains of this type may be treated as INKS (IRON). Argyrol and other silver stains may be removed by treatment with an excess of potassium cyanide solution (POISON!). This reagent converts the metal to a soluble form that can readily be washed out.				
MILDEW.	Fresh, light stains are removed in the standard washing process. Old stains, however, must be treated with javelle water alternated with oxalic acid.				
MUD.	Removed in the standard washing process. Occasionally there is a residual iron stain that must be treated [see INKS (IRON)].				
PAINT AND VARNISH.	These stains are more easily removed if treated before being laundered. Oleic acid is rubbed into the spot, and the stain is washed with a 1 per cent. solution of oleic acid in kerosene (prepared by dissolving two ounces of the fatty acid in a gallon of kerosene). Repeat the treatment with the kerosene-oleic acid solution, and wash with warm soda ash solution (6 ounces of soda ash to a gallon of water).		Use the following solvents: Turpentine, benzene, carbon tetrachloride, or chloroform.		
PERSPIRATION.	If not removed in the standard washing process, treat with javelle water, or with potassium permanganate solution followed by oxalic acid.		If the stain does not wash out, use potassium permanganate solution followed by oxalic acid.		Where the color is changed, it may sometimes be restored by sponging with a weak acid or alkali.
SCORCH.	Light spots will be removed in the standard washing process, but heavier spots must be specially treated. For this purpose, javelle water, alternated with oxalic acid, may be used; else potassium permanganate solution followed by sodium bisulfite.		Treatment with permanganate solution will partially restore scorched wool and silk, but a heavy scorch can never be removed.		
SYRUP.	Sugar is removed in the standard washing process. Fruit syrup stains remaining after this treatment should be dealt with as described under FRUIT.				
TAR OR TARRY.	See treatment for PAINT.				
TEA.	Tea stains are usually removed in the standard washing process.		Such stain as remains after the standard washing process may be treated with hydrogen dioxide, or with permanganate solution, followed by oxalic acid solution.		
TOBACCO: EXTRACT.	If not removed in the standard washing process, either javelle water or a solution of potassium permanganate followed by oxalic acid may be used.		The substances comprising a tobacco stain are soluble in 95 per cent. ethyl alcohol. Hydrogen dioxide or permanganate solution may be used on any traces that remain after treating with alcohol.		
TARRY RESIDUE FROM PIPES.	See treatment for PAINT.				
TURMERIC.	Usually removed in the standard washing process; if not, treat with javelle water or with potassium permanganate solution. This dye is one of the few permitted to be used in food by the Bureau of Chemistry's interpretation of the Pure Food Law. Some of these permitted dyes resist the action of the above reagents, but they can all be removed with amyl alcohol.		A stain which survives the standard washing process can be treated with potassium permanganate or hydrogen dioxide solution. The discussion of the other dyes used in foods, as given for cotton and linen, holds for wool and silk also.		
VASELINE.	See treatment for WAX.				
VERDIGRIS.	Usually removed in the standard washing process. Older stains may require more drastic treatment, as, for example, with dilute hydrochloric (muriatic) acid.				
WALNUT (BLACK).	Boil in a concentrated soap solution and follow with treatment with javelle water if the gray stain persists. For old stains soak in javelle water, rinse, treat with oxalic acid, and rinse again. This treatment is not always successful.		No treatment can be recommended for wool and silk.		
WAX: PARAFFIN AND OTHER WAXES.	These substances must be sponged with a suitable organic solvent (gasoline, chloroform, benzene, carbon tetrachloride, etc.), or placed between two layers of clean, absorbent material, such as blotting paper, and pressed with a warm iron. The blotting paper removes the paraffin by capillary attraction after the heat has converted it into a fluid state.				

The Treatment of Stains*

Methods of Stain Removal Adapted to Various Textiles

By Harvey V. Elledge and Alice L. Wakefield
Industrial Fellows of the Mellon Institute of Industrial Research

In our issue of May last we published an article on "Textile Fibers" in which tests were given for the identification of various fibers in common use. The article was abstracted from a booklet published by the Laundryowners National Association, entitled "The Conservation of Textiles." Another chapter from the same source is reproduced by courtesy of the publishers. Although written especially for laundry owners the subject is of general interest, and the accompanying chart together with the instructions for removing stains will no doubt prove valuable to the majority of our readers. —Editor.

OUR best advice to the laundryowner is that he choose one of his employes who shall handle all stained fabrics which require special treatment. Such a procedure cannot be urged too strongly because the proper treatment of stains is dependent upon an intimate knowledge of their physical and chemical characteristics and a thorough training in the technic of the application of this knowledge. The physical characteristics of stains are differentiated by such slight degrees in so many cases that word-pictures make an impossible medium for instruction; rather a keenness of perception and a large power of retention, combined with the consistent application of these faculties are necessary for the development of a good "stain identifier."

Having provided oneself with a trained observer, or with a person capable of being trained to observe, the thing to do is to provide a special work bench for the application of the specific knowledge of stain treatment. Only a small bench will be necessary, say the size of an ordinary kitchen table, but it should be given up entirely to the work under discussion and should be specially equipped. It would be well to remember, when choosing the location of this bench, that at times inflammable materials will be used.

In the first place it should be placed in the best light obtainable. This is desirable that slight color differences may be noted and that final results may be accurately judged as complete or partial removal. If only partial removal has been effected, efforts may be renewed along different lines until the stain is completely removed or until the best possible results have been obtained.

The equipment should include all the reagents used in the identification and removal of stains and any apparatus that will facilitate their application. The reagents to be desired are presented in the table on page 54.

There should be "stock" bottles of each reagent; that is, bottles in which the reagent is kept in its original condition and strength. These will be handled only when the solutions to be used in stain treatment are made up. There should be the bottles of solution that are to be kept on hand as "indicators" and as "testers."

The solutions should be carefully prepared. There is no need for using excessively strong solutions because the lessening of the time factor by this method means a corresponding increase in the tendency of the solution to tender the fabric. It is just as profitable for the person who is removing stains "to increase the dose" as it was for the man who increased the dose of headache tablets, and died as a consequence. In both cases the physical condition of the object under treatment is made worse instead of better.

Oxalic Acid.—One ounce of oxalic acid crystals are dissolved in a gallon of water. This solution works more rapidly when warm. Always rinse carefully in clear water after using this acid; if traces of it are left in the fabric it becomes concentrated as the moisture evaporates and tenders the cloth.

Acetic Acid.—This acid is usually found in the laundry as commercial 56 per cent acetic. It can be used in this strength without damage to the fabric, but it is preferable to dilute it with an equal amount of water. As this acid is volatile, that is, as it evaporates with the water, concentration does not occur with drying and tendering does not result from insufficient rinsing.

Hydrochloric Acid.—This acid should be used in weak solutions, not exceeding a 10 per cent solution. This percentage may be purchased from the drug store, and care should be taken to express the percentage desired as it is prepared for pharmaceutical purposes in 10 per cent, 25 per cent and 37 per cent strengths. Careful rinsing is urged with this acid for the same reason that is given under oxalic acid.

Caustic Soda.—A 5 per cent solution is prepared by dissolving an ounce of the solid in a pint of water. This solution is to be used on cotton and linen fabrics only and followed by a good rinsing. The concentration of the 5 per cent solution is not detrimental to these fibers, but in greater concentrations tendering is effected.

Ammonia.—The ammonia sold by druggists is about a 10 per cent solution. It will never be found necessary to use it in this strength and dilution with ten times its volume of water is advised.

Javelle Water.—This reagent is so well known in the laundry that no other discussion will be given than that it is prepared as directed in the L. N. A. "Standard Formulas for Washroom Practice," Chart No. 1. The stock solution resulting from this formula should be diluted at least fifty times before using on fabrics. If rinsing is done with dilute acetic acid water the activity of the bleaching solution will be killed.

Hydrogen Dioxide.—Commonly called hydrogen peroxide, and purchased at the drug store, this reagent may be used full strength. The commercial grade of hydrogen dioxide usually contains a considerable percentage of free sulfuric acid; for this reason great care should be used in rinsing after this reagent has been used. Owing to the presence of the small amount of acid that has produced corrosion when used ignorantly, the idea has sprung up that hydrogen dioxide itself is corrosive. This is not the case, however, and no hesitancy should be felt in using it as a stain remover.

Potassium Permanganate.—One ounce of the crystals is dissolved in a gallon of water. A stronger solution is capable of burning the fabric as effectively as a flame, so should never be used.

Sodium Perborate.—This reagent may be used in solutions of any strength, or made into a paste with water and spread on the fabric to be treated.

Sodium Bisulfite.—A saturated solution of this reagent is prepared by adding it to the water until no more will go into solution. Sodium bisulfite is used alone and in connection with powdered zinc. When zinc is used it should be put into small bags so that it will not settle on the fabric and leave a stain that can only be removed with an accompanying damage to the fabric.

Oleic Acid.—This reagent may be purchased under the trade

TABLE OF REAGENTS USED IN STAIN REMOVAL

Indicators	Acids	Alkalies	Oxidizing Reagents	Reducing Reagents	Solvents	
Phenolphthalein Methyl orange Hydrochloric acid and Potassium sulfocyanide	Oxalic Hydrochloric Acetic	Caustic soda Soda ash Ammonia Potassium cyanide	Javelle water Hydrogen dioxide Potassium permanganate Sodium perborate	Sodium bisulfite Sodium bisulfite used with zinc Sodium thiosulfate	Ethyl alcohol Amyl alcohol Ethyl ether Acetone Aniline Chloroform	Carbon tetrachloride Carbon disulfide Benzine Kerosene Gasoline Oleic acid

name of "Red Oil," but an effective substitute for it can be prepared in the plant by dissolving some soap in hot water, precipitating the fatty acids by acidifying with strong acid, heating till separation is complete and then cooling. After cooling, the fatty acid will be found as a solid cake on the surface of the water.

Sodium Thiosulfate.—Used in saturated solution, prepared by adding crystals to water until no more can be dissolved.

Potassium Cyanide.—One ounce of the crystals is dissolved in a gallon of water. This reagent is one of the most deadly poisons known; therefore great care is to be observed in its use. If any of it gets on the hands they should be kept away from the rest of the body and from the clothing until they can be washed well. The solution should be thrown out immediately after the treatment is completed, the utensils used with it washed thoroughly, and the bench cleaned of any splashings it may have received. If these precautions are observed no fear need be entertained concerning the use of this reagent.

The successful application of these solutions requires a few common utensils that are listed herewith:

Hotplate (electric or gas),
Nest of enameled bowls,
Scales,
Glass rods (with rounded ends),
White blotting paper.

The actual discussion of the treatment of stains had best be made to follow the *Procedure Chart for the Removal of Stains from Wash Goods*, and will occupy the remainder of this chapter.

Albumin.—The regular standard washing process includes a lukewarm first bath for the purpose of dissolving any albuminous materials that may be present.

Blood.—The albuminous portion of this stain is removed in the first bath of lukewarm water; the stain proper, which is due to the hemoglobin or coloring matter of the blood, is removed in the bleach bath. If the fabric is of the kind that can not be treated with javelle water the stain may be treated with hydrogen dioxide.

Bluing.—Bluing is of three kinds, ultramarine blue that gives the desired color by depositing small insoluble particles of blue on the fabric; prussian blue that dyes the fabric with a soluble dye; and aniline blue that dyes the fabric with an insoluble dye. Ultramarine blue, which only gives trouble by being used too heavily, may be removed by simple washing; prussian blue, which in an alkaline bath is changed to iron oxide and gives a rust stain, has to be treated with oxalic acid solution. The aniline blues, if used too freely, dye the fabric permanently as far as the ordinary solvent, water, is concerned, and must be removed by treatment with oxidizing or reducing agents, according to the nature of the dye used. Javelle water or potassium permanganate solution is used to oxidize these blues on cotton or linen fabrics, while potassium permanganate solution or hydrogen dioxide is used on silk and wool. Sodium bisulfite solution and zinc may be used on both the animal and vegetable fibers as a reducing agent. The potassium permanganate solution treatment is not complete in itself, as it leaves a brown stain of manganese dioxide in the cloth which must be removed by treatment with oxalic acid solution. If it is found necessary to repeat the treatment the excess oxalic acid should be washed from the fabric before more permanganate solution is applied. It is always well to observe the precaution of rinsing from the fabric any excess of solution when two solutions are alternated, because the excess of solution present reacts to neutralize the effect of the other solution in a manner that has no effect in the removal of the stain. There is no need for such useless reactions.

Cocoa and Chocolate.—These stains occur in most cases on white table linens and, when too deep to be removed by the water and soap, are removed by the bleach bath.

Coffee.—Javelle water, applied in the bleach bath, removes this stain effectively.

Cream and Ice Cream.—The principal ingredient that causes trouble in this type of stains is the butter fat present. When this is removed with hot water and soap the stain is usually gone completely. In the case of an ice cream that has fresh fruit juice or a food dye present as coloring matter the stain will be removed by javelle water.

Dyes.—The treatment for a dye stain has always to be determined by a few tests on some portion of the stained fabric. The first trial may be made with javelle water; then with permanganate solution, then with sodium bisulfite solution and zinc. The kind of material involved and the dye itself have to be taken into consideration for the successful treatment of this type of a stain. The removal of hat dyes is facilitated by treatment with 95 per cent ethyl alcohol, in which the greater portion of the dye is soluble. A residual stain may have to be treated with one of the oxidizing or reducing agents prescribed on the chart.

Egg.—This stain is partly albuminous, partly fatty, and, in most cases, will be removed by a formula that includes a lukewarm first bath and hot suds.

Fruit.—Fruit stains can readily be removed by treatment with javelle water; for that reason the stains appearing in cotton and linen garments are said to be removed in the standard washing process. Silks and wools are to be treated with the reagents given in the chart that are not detrimental to them.

Grass.—This stain is also removed from cotton and linen by treatment with javelle water. Silks and wools are treated with a mixture of equal parts of ethyl alcohol and ethyl ether. This is a solvent for the green dye present in grass.

Grease.—The average grease stain is removed in the standard washing process. Any stain that survives this treatment may be softened with oleic acid and lard and washed in a hot solution of soda ash. If the grease has contained a mineral staining agent like iron or some type of dyestuff it can be treated specially as described under these headings. The best treatment to be accorded to silks and wools is with one of the many grease solvents given on the chart. The solubilities of the different types of grease vary with the different solvents, and it is often necessary to experiment with several solvents before the most efficacious one is found.

Gum or Resin.—The type of the gum or resin decides the solvent that should be used. Common chewing gum is soluble in carbon tetrachloride; varnish is soluble in alcohol; resins are soluble in ether, alcohol and turpentine, the source of the resin determining which solvent is best. Since there is no way to decide which resin is present, the method of trial

and error must be applied to discover which solvent is to be used.

Ink.—Iron inks are best removed by treatment with warm oxalic acid. If such treatment does not remove the stain completely it is possible that the ink has been a mixture of iron ink and an aniline dye, in which case a second treatment with javelle water is necessary. India ink and printers' ink are both suspensions of carbon in a gum-like medium, and should be removed in the regular laundering process. If such treatment is not effective the stain may be loosened with lard and laundered again. Silver nitrate inks have to be treated with sodium thiosulfate or with javelle water. Javelle water converts the silver to an insoluble colorless salt that has to be removed by treatment with dilute ammonia water. If this precaution is not taken the silver may again oxidize to the colored salt and the stain reappear. Indelible pencils contain both graphite and an aniline dye; the dye can be removed by treatment with javelle water, while the graphite will be washed away mechanically.

Iron.—The specific treatment for iron stains is warm oxalic acid solution.

Leather.—Javelle water has been found to remove these stains from the cotton and linen fabrics, but in the case of silks and wools the stain is permanent.

Medicines.—The medicines containing organic materials are usually removed in the regular laundry process; any stain surviving this treatment can be treated with javelle water. The medicines containing salts of the heavy metals, like iron, silver, etc., may be treated with potassium cyanide. The cyanides of these metals are water soluble and are removed by means of this solvent after conversion has taken place.

Mildew.—These stains are usually removed in the standard washing process, but heavy stains may have to be treated alternately with javelle water and oxalic acid.

Mud.—The mud itself is removed in the regular water washing but a residual stain of iron is often encountered. This is treated as all iron stains are, with warm oxalic acid.

Paint and Varnish.—These stains are best removed before laundering. They may be loosened by treatment with oleic acid and then laundered or they may be treated with one of the solvents that are given in the table of reagents. The character of the paint determines the treatment applied. Paints are composed of some vehicle and a pigment; the vehicle hardens or sets by the evaporation of some volatile ingredient or by the absorption of oxygen from the air, depending upon its chemical nature. The pigment can be removed mechanically after the vehicle carrying it is dissolved again.

Perspiration.—This stain, being water borne, is usually removed by simple soap and water washing. If it is connected with the running of a dye, treatment for the dye must be applied. Colored goods that have been discolored by perspiration may sometimes be restored by sponging with weak acid or alkaline solutions.

Scorch.—Scorched cotton or linen may be restored by treatment with javelle water alternated with oxalic acid solution, provided the scorch has not completely destroyed some of the fabric. The same results may also be obtained with potassium permanganate and sodium bisulfite solutions. Light scorches on silk and wool may be partially restored by treatment with permanganate solution, but nothing can be done for heavy scorches on these fabrics.

Syrup.—Syrup stains are usually removed in the standard washing process because the medium of the stain, the sugar, is removed. If a fruit juice has been present, some stain may survive this process but the treatment described under Fruit will remove it satisfactorily.

Tar and Tarry.—See treatment of paint.

Tea.—Tea stains are usually removed in the washing process, but the occasional heavy one should be treated with javelle water when it appears on cotton and linen and with potassium permanganate or hydrogen dioxide when it appears on silk or wool. This stain is, in most cases, the result of the tannin present in the tea but in some cases is due to a dye that is added to give a darker color to the infusion.

Tobacco.—The stains from tobacco are usually soluble in the standard washing process, but occasionally stains that require longer treatment are encountered. They may be treated with the oxidizing agents that are permissible with the type of fabric involved or they may, in case of the tarry residue from pipes, be treated with ethyl alcohol.

Turmeric.—This is one of the seven dyes permitted by the United States Pure Food law to be used in food stuffs. They are usually to be removed by treatment with javelle water or permanganate solution, but in cases that do not respond to this treatment amyl alcohol will be found effective.

Verdigris or Copper Stains.—This stain, if not removed by the usual laundry process, has to be treated quite drastically with dilute hydrochloric acid. If only a weak solution of acid is used and care is taken to remove all traces of it afterward, no ill results will be noticed.

Walnut.—This stain is one of the worst encountered on fabrics. It can usually be reduced to a light gray color on cotton and linen by treatment with javelle water, but when on silk and wool no treatment can be recommended.

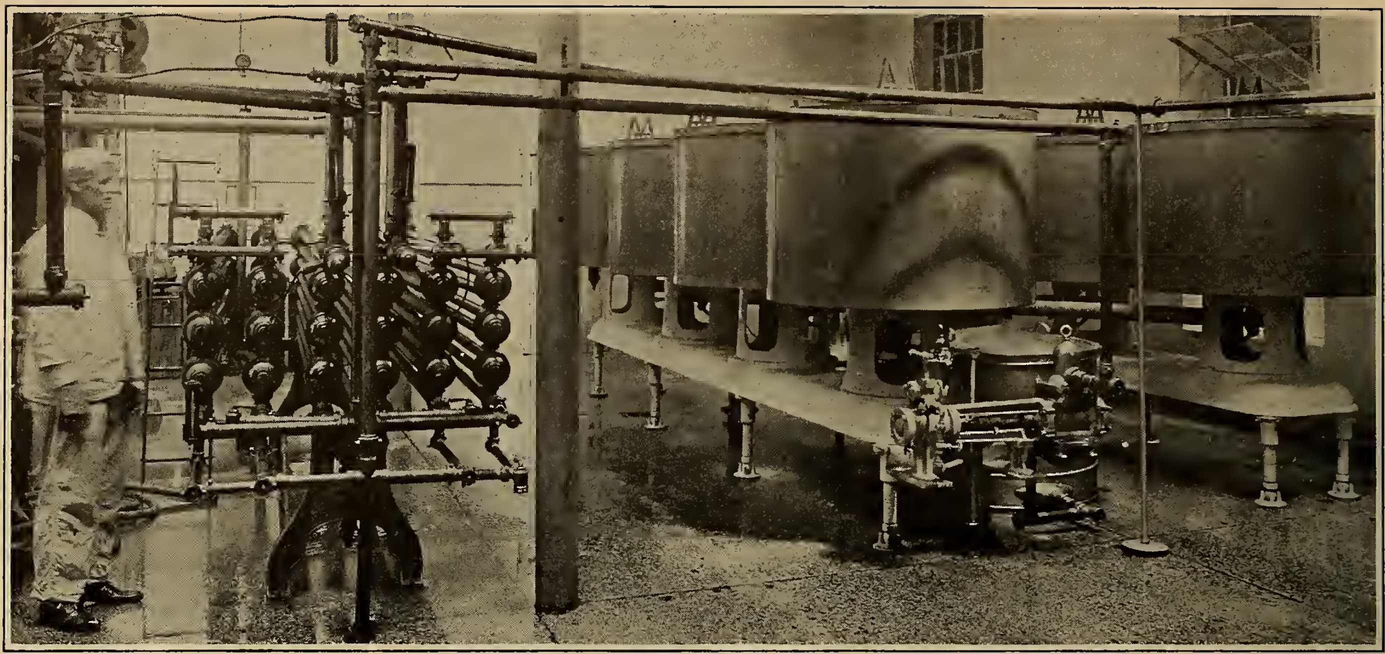
Wax.—The most satisfactory method of removing waxes from fabrics is to place the spot on a piece of blotting paper and apply a warm iron. The heat liquefies the wax and the blotting paper absorbs it. If traces remain after this treatment they may be sponged away with one of the organic solvents.

In conclusion, it is appropriate to suggest that inspection of garments for stains be rigidly maintained in the receiving room. Many times stains are set in laundering and offer a greater problem for removal than they otherwise would.

PERMEABILITY OF BALLOON ENVELOPES

It has been learned that gases do not pass through rubber according to the simple law formulated by Graham. Both Graham's own researches and those of other investigators show that in this case the phenomenon is much more complex. A German scientist, named W. Franzer, writing in the *Chemiker Zeitung* (Berlin) for August 19, 1920, sums up the work done in the last few years in measuring the velocity with which a rubber membrane or a balloon envelope is traversed by gases, and shows that until recent years the studies published upon this question contained many errors, because of the fact that the hydrogen which had passed through the membrane was weighed in the form of water. Mr. Franzer has devised a method of measurement by means of an interferometer which gives figures strictly proportional to the rate at which the hydrogen passes through the membrane. The results obtained prove that the rubber behaves differently according to whether it is saturated with hydrogen or not.

For a given difference of pressure between the two enclosures separated by the membrane and at a given temperature the velocity of the diffusion of the hydrogen increases, starting from the moment when the membrane or the rubber finished cloth comes in contact with the hydrogen until the moment when the membrane is completely saturated with the hydrogen, after which the rate remains practically constant. This point is rapidly reached when the cloth or membrane has previously been in contact with hydrogen. If the inside surface of the cloth is saturated with hydrogen and if its external surface is in contact with a medium containing no hydrogen then the velocity at which the gas passes and the degree of permeability are both proportional to the rise in temperature. They also increase with the difference of pressure between the two surfaces—in this case, however, not in the same ratio but more slowly. Rubber finished fabrics behave like rubber itself so long as their degree of elasticity is the same. When the pressure becomes higher the permeability increases with the pressure at a very slow rate, since the fabric is less elastic than the rubber and, therefore, prevents the elasticity of the latter from manifesting itself.—Translated for *The Scientific American Monthly* from *Le Genie Civil* (Paris).



PASTEURIZING APPARATUS IN A LARGE NEW YORK MILK DISTRIBUTING PLANT

Clean Milk for Consumers

Present-Day Technique in the Production and Care of Milk

By May Tevis

ONE of the earliest animals to be domesticated even among nomadic tribes was the cow. So valuable is the precious fluid secreted by this dull but worthy animal that in some countries she has even been given divine honors. In India children are taught to revere the cow as their "second mother" and crown them with garlands on certain festival days. So strong is this feeling, according to a Hindu acquaintance of the writer, that an orthodox Hindu would shrink from eating beef as the European or American would from cannibal practises!

But valuable as milk is even for adults and essential as it is in many cases for children, mankind has learned in the last few decades, particularly since the pioneer discoveries of Pasteur, that milk may be a very deadly menace to the health and lives of those who partake of it. This is because it is one of the most favorable of all culture mediums for various disease germs, such as the typhoid bacillus, etc. It is not improbable, indeed, that in the comparatively recent past, after the shipping of milk in large quantities from mixed sources, to cities, because common and before the necessity of modern sanitary precautions was understood, hundreds of thousands of children and adults have been victims of disease carried by milk.

We shall not undertake to discuss the merits of the controversy as to how far bovine tuberculosis is responsible for that disease in human beings. It is our chief purpose here to give an account of the modern practise required by state and city authorities for the purpose of preventing producers and distributors from furnishing helpless consumers with milk dangerous to health from its bacterial content, inferior in nutrive quality, or contaminated by avoidable dirt.

In order that the milk shall contain the required amount of solids and of butter fat it is essential that the breed of the cow be considered first of all. Holsteins, for example, give enormous quantities of milk but it is thin and poor in quality. Jerseys and Alderneys, on the other hand, give a very rich milk, but it is apt to be lower in yield. Not only breed, however, but individual capacity must be taken into account in this connection.

Uses to which Milk Is Put (Calculations Based on Estimates)

Item	lbs. of Milk	Per Cent
Product of 22,768,000 cows at 3,716 lbs. per animal	84,611,350,000	
Disposition of milk product:		
1,650,000,000 lbs. of butter (at 21 lbs. milk)	34,663,850,000	41.0
420,000,000 lbs. of cheese (at 10 lbs. milk)	4,200,000,000	5.0
975,000,000 lbs. of condensed milk (at 2½ lbs. milk)	2,437,500,000	2.9
210,000,000 gals. of ice cream (weighing 6 lbs. to the gallon, 10% fat)	3,150,000,000	3.7
100,000,000 persons; 45% at 0.7 lb. a day (cities) farms with dairy cows, 30%, 1.5 lbs. per day; other farms and small towns, 25%, 1 lb. a day, approximately	36,500,000,000	43.1
17,500,000 calves, whole milk (estimated) requirement	3,660,000,000	4.3
Total	84,611,350,000	100.0

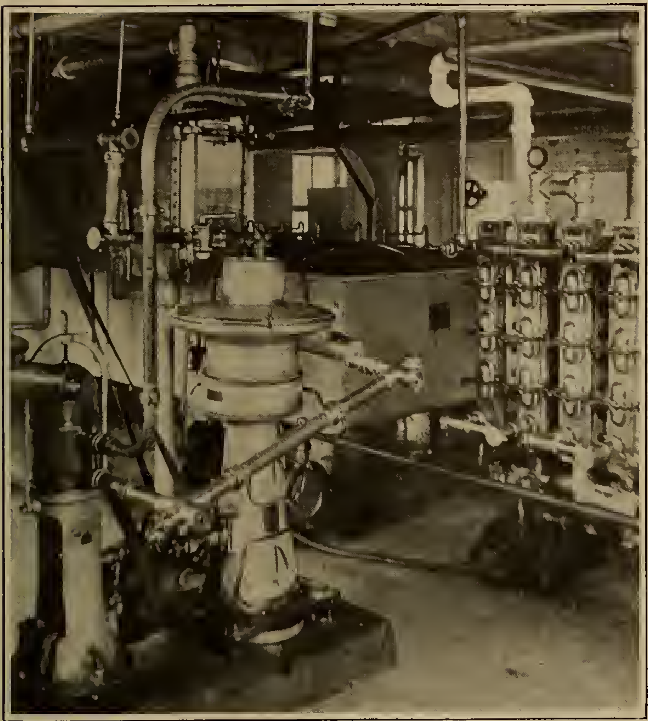
The grades and standards recommended by the National Commission on Milk Standards are as follows:

GRADE A

Raw Milk.—Milk from this class shall come from cows free from disease as determined by tuberculin tests and physical examinations by a qualified veterinarian, and shall be produced and handled by employees free from disease as determined by medical inspection of a qualified physician, under sanitary conditions, such that the bacteria count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score at least 80 on the United States Bureau of Animal Industry score card.

Pasteurized Milk.—Milk of this class shall come from cows free from disease as determined by physical examinations, and

shall be produced and handled under sanitary conditions, and that the bacterial count at no time exceeds 200,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacterial count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score 65 on the United States Bureau of Animal Industry score card.



CENTRIFUGAL SEPARATOR FOR REMOVING FOREIGN MATTERS FROM MILK

GRADE B

Milk of this class shall come from cows free from disease as determined by physical examination, of which one each year shall be by a qualified veterinarian, and shall be produced and handled under sanitary conditions, such that the bacteria count at no time exceeds 1,000,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacterial count shall not exceed 50,000 per cubic centimeter when delivered to the consumer.

It is recommended that dairies producing grade B milk should be scored and that the health department or the controlling departments, whatever they may be, strive to bring these sources up as rapidly as possible.

GRADE C

Milk of this class shall come from cows free from disease as determined by physical examinations, and shall include all milk that is produced under conditions such that the bacterial count is in excess of 1,000,000 per cubic centimeter.

All milk of this class shall be Pasteurized, or heated to a higher temperature, and shall contain less than 50,000 bacteria per cubic centimeter when delivered to the consumer.

Whenever any large city or community finds it necessary, on account of the length of haul or other peculiar conditions, to allow the sale of grade C milk, its sale shall be surrounded by safeguards such as to insure the restriction of its use to cooking and manufacturing purposes.

These grades and standards have been adopted either directly or with such modifications as local conditions might suggest, in several of the states and cities of the United States, and it seems certain that such grading of the milk supply will soon become the general rule.

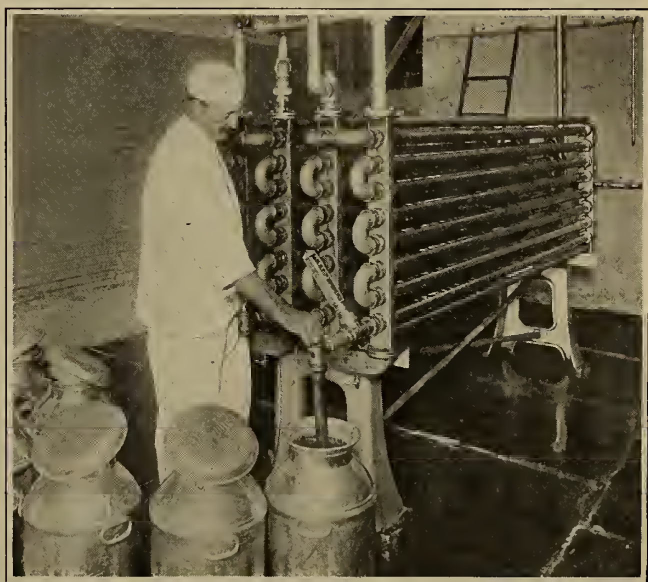
Pasteurization.—Since under ordinary conditions it is not always possible to guard perfectly against the possible introduction of the germs of communicable disease into milk, and since it is now known that a careful application of a suitable degree of heat for a definite period of time will rid the milk of disease germs while injuring its nutritive quality but little, it is generally agreed among authorities that all milk, except certified milk produced under what are popularly called gilt-edge conditions, should be pasteurized, according to the process invented by the famous French savant. This process consists of heating the milk for 20 to 30 minutes at a temperature of 60 to 63 deg. cent. (145 deg. fahr.) Practically the only injury exerted upon the milk when the temperature is kept at this low point is a loss of its vitamines. This is not an especially serious matter in the case of adults living upon a liberal mixed diet, since they may obtain these necessary elements from many other sources, particularly fruits, salads, and green vegetables. But when it is necessary to feed babies and young children upon pasteurized milk they should also be given orange juice at frequent intervals, since this is both easy to digest and uncommonly rich in vitamines.

It must not be forgotten that pasteurized milk becomes freshly contaminated with great rapidity unless care is taken to preserve it in a sterile condition.

Preservation of Milk.—As in the cases of other foods strict cleanliness and the use of sterilized utensils form the best means of preventing deterioration, since in this way the bacteria can be either prevented from entrance entirely, or else retarded in growth, if not destroyed utterly. It has been found by actual experiment that perfectly clean milk protected from air and kept cold will remain sweet and fresh for two or three weeks, if not longer, without other measures.

The superiority in the methods of the best American dairies with respect to cleanliness, was strikingly shown in the Paris Exposition of 1900. Three great dairies supplying metropolitan distributors, one in New York, one in New Jersey, and one in Illinois sent regular shipments of fresh milk and cream to Paris during the summer. These supplies were found to be perfectly fresh and sweet when opened 15 or 20 days after bottling which made European dairy experts express great surprise that the milk had been thus preserved merely by being kept clean and cold.

Certain chemical preservatives are effective in keeping milk from turning sour, though their use is much to be deprecated. The preservatives generally used are formaldehyde and borax or boracic acid. Much more objectionable is the use of ordinary soda, either washing or baking soda, to keep milk



COOLING MILK BEFORE PUTTING IT INTO CANS FOR SHIPMENT IN REFRIGERATOR CARS

sweet, since in this case the alkali merely neutralizes the lactic acid which would otherwise give the milk a sour taste. The soda does not check the growth of the bacteria but merely hides the results of their growth. Moreover, by neutralizing the lactic acid, which affects chiefly the content of milk sugar, the soda actually favors the growth of other bacteria which feed upon the casein in the milk. Such milk, therefore, actually becomes unwholesome much faster than that to which nothing has been added.

MILK ANALYSIS

The fat content of milk, *i.e.*, the percentage of cream or butter, is of peculiar importance, since aside from its nutritious quality it contains an almost essential fat-soluble vitamine. In some remarkable experiments conducted in Germany during the war to determine the nutritive quality of various foods, it was found that only one or two other fats (one of which was cod liver oil) were capable of taking the place of butter in the diet of rats, which like man are omnivorous. Animals supplied with the most liberal diet, including fats as well as sugar, starches, and proteins, sickened and died unless the diet contained one of these essential forms of fat, preferably butter.

Various tests have been devised for determining the percentage of butter fat in milk, one of the best being that devised by Dr. S. M. Babcock of the Wisconsin Agricultural Experiment Station.

Percentage of Butter Fats.—The "richness" of cream or milk and their value depend upon the amount of butter fat in them. So cream or milk is often called "30% cream" or "20% cream" or "41% milk," according as 30% or 20% or 41% of the fluid is butter fat; 31% cream is quite rich, ordinary market cream varies between 18% and 40%, though it may fall below 18%, or it may be sold as a very expensive article having as high as 60%. Rich milk may contain more than 6% of butter fat and skim milk less than 0.1 of one per cent. The average for good whole milk is between 3% and 4½%.

For a long time scientists and scientific dairymen were the only ones to speak of milk and cream in terms of percentage of butter fat. "Now, however, people are beginning to realize how valuable a part of the milk the butter fat is, and are paying more attention to the actual percentage of butter fat in the cream or milk they use. So it is no longer unusual to see a dairyman advertise cream of a certain percentage or to hear a housewife ask for it specifically," says a recent authority.

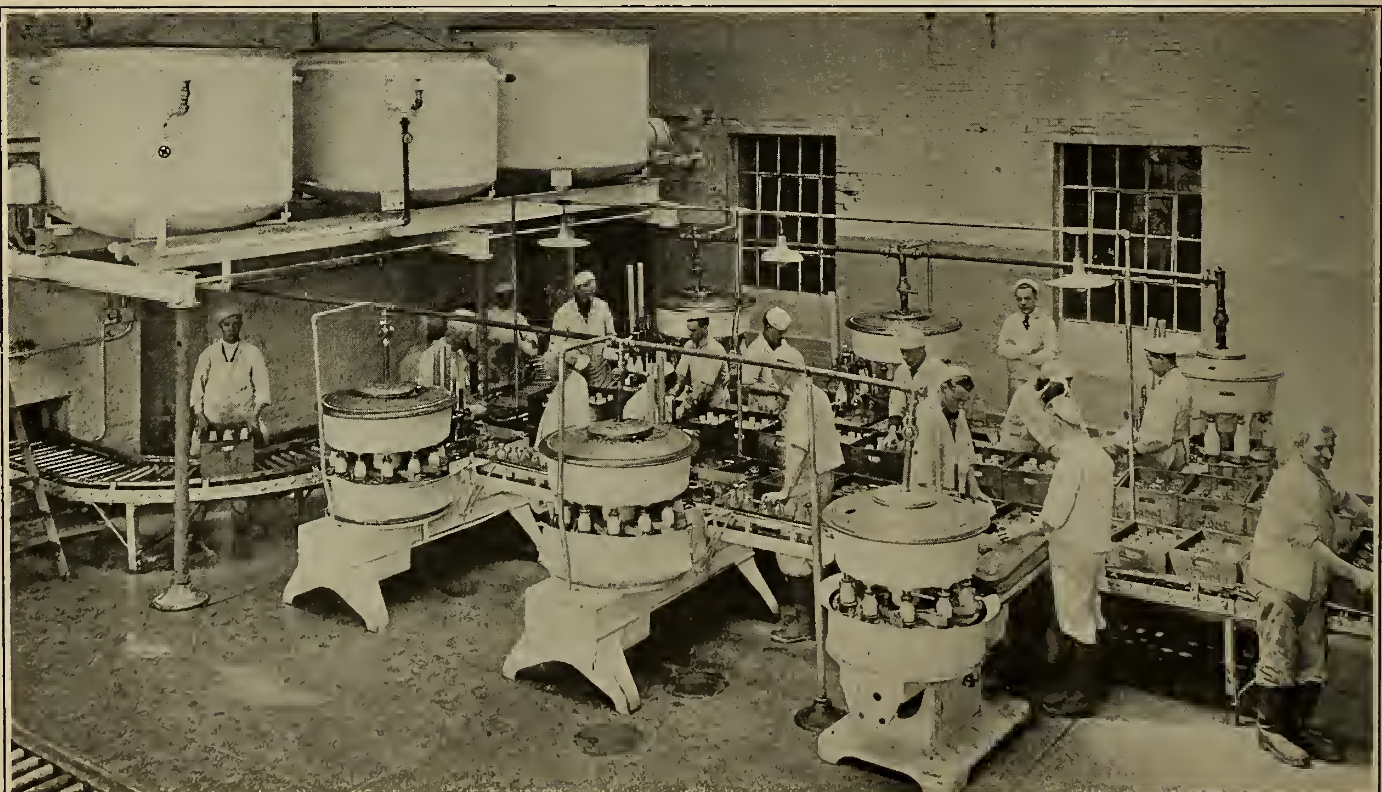
Pasteurized Cream.—This does not look so rich as raw cream, and fresh, sweet cream appears to be thinner than when it is 24 hours old and slightly ripened. So it is well, when buying cream, not to judge by appearances. Demand of the milkman that the cream shall have a certain percentage of butter fat and insist on getting what you pay for. If you have no Babcock tester the milk inspector will test the cream for you.

In making the Babcock Test, a measured amount of milk is treated with about an equal volume of commercial concentrated sulphuric acid which dissolves the other constituents, leaving the fat free in a heavy solution from which it is separated by centrifugal force and collected in the graduated neck of the test bottle, where its volume is read off at ease on the completion of the test. Complete directions are furnished with the testing outfit, which can be purchased for a few dollars from dealers in chemical apparatus or dairy supplies.

TESTING THE COWS

This matter of individual capacity both for yield and for quality is so vitally important that a farmer may actually lose money by keeping milch cows which give so low a yield or so poor a quality of milk that its sale price is less than the cost of the care and feeding of the cow. In such a case the animal is "eating her head off," and milking the farmer's pockets, so to speak. For this reason the milk from each cow is weighed at regular intervals, once a month or oftener, while the Babcock Test is also applied three or four times during the period of lactation. If yield and quality prove that the cow is not worth her keep then "off with her head" the sooner the better.

Health Tests.—The cow must also be tested for tuberculosis, which is done by the application of Koch's well-known Tuberculin Test. While it is not necessary to kill animals which are only slightly infected, this should be done when the lungs or udder are affected. In his recent work "The Story of Milk,"



A BATTERY OF AUTOMATIC BOTTLING AND CAPPING MACHINES

CHEMICAL AND BACTERIOLOGICAL LABORATORY WHERE SAMPLES OF MILK FROM VARIOUS COLLECTING STATIONS ARE EXAMINED TO ASCERTAIN THEIR QUALITIES AND KEEP THE MILK UP TO STANDARD

Johan D. Frederiksen quotes with approval the system of isolating infected animals introduced into Denmark by Dr. Bernhard Bang. This system, combined with compulsory pasteurization of the milk from an affected cow has proved effective in eradicating bovine tuberculosis.

CARE OF MILKING

While milk is almost free from bacteria as it comes from the cow, it is one of the best culture mediums in the world for human disease germs. Hence it is important not only that the cows themselves shall be healthy and clean, but that the milkers shall be in the same condition as regards their own bodies and that their clothing shall be freshly washed. The udders and teats of the animal must be carefully washed, the barn must be kept scrupulously free of dirt and, above all, the ubiquitous fly which, as we now know, is one of the most active agents of infection, must be excluded.

The test for clean milk generally used is called the *Bacterial Count;* it consists of the estimation of the number of bacterial colonies per cubic centimeter. Even fairly good milk often contains several hundred thousand bacteria per cubic centimeter, but where scrupulous cleanliness is observed, as in the preparation of certified milk, this number may be reduced to less than a thousand. City ordinances vary as to the permissible limits in certified milk, ranging from 10,000 to 30,000 per cubic centimeter. These numbers sound rather appalling, but we must remember that large as they are, they are not more than the resistant forces in a healthy human body are equipped to combat.

PRACTICE AT MILK STATIONS

In various parts of the country there are stations for receiving milk, sometimes controlled by coöperative societies of farmers and sometimes by the big distributors. In these the milk is tested and if not up to the standard is sent back to the producer. One sample is taken for the Babcock Test and another for the Fermentation Test. Each producer's delivery is weighed in the "weigh can" and then run through a cheesecloth strainer. In some stations the milk is merely cooled by running it over a cold water or brine cooler and then placed in the shipping cans, after which it remains in ice water or in a refrigerator until picked up by the milk train. In others it is run through a centrifugal machine to clarify it, the impurities being thrown out and deposited on the wall of the vessel, after which the milk is pasteurized and bottled before being shipped. Whether pasteurized in bottles in the country or at the city plant, great care is taken to fulfil sanitary requirements as well as to secure economy. These plants are equipped with very ingenious bottling machines and bottle washing machines as well as with pasteurizers.

CHEMIST TESTING SAMPLES FROM THE PASTEURIZING ROOM

SEPARATING THE CREAM

The writer has a charming memory of the dairy house or "spring house" on her great grandfather's farm in Kentucky. A low stone structure built above a spring of cool water. Here the freshly drawn milk was placed in shallow pans so as to cool quickly and so as to facilitate the rising of the cream by affording it a large surface. Nowadays, however, there is no waiting for the cream to rise, no picturesque skimming of the golden surface with a shallow skimmer. The fresh warm milk is run at once in a steady stream through a machine known as a separator; this separator likewise operates by centrifugal force. There are many separators on the market, but that designed by Dr. Gustaf De Laval is, perhaps, the most successful, and is now used all over the world. The cream runs out through one tube and the skimmed milk by another. By regulating the cream outlet "heavy" or "light" cream can be produced at will. These machines are run either by hand or by power; the former will separate from 200 to 1,000 lbs. of milk per hour and the latter 6,000 lbs. or more. The cream

is graded according to its richness. Ordinary milk contains 4 per cent butter fat. If 1/8 of this milk is separated out containing all the butter fat the cream will, of course, be 8 times as rich as the original milk and is known as 32 per cent cream. If only 1/4 is taken 16 per cent cream is produced.

Standardizing Cream.—Rich cream is often reduced to a lower standard, especially for the purpose of making modified milk for infants, or for sale to ice cream manufacturers. Cream to be whipped must be from 24 to 32 per cent rich and must be cold and properly "aged," *i.e.*, it must be kept in ice water from 12 to 24 hours.

Buttermilk and Fermented Milk.—Old-fashioned buttermilk was delicious when drunk fresh from the churn, especially with the golden flakes of butter still swimming temptingly in it, but after the separator came into use the sour, stale, skimmed milk called buttermilk ceased to be appetizing to country-bred persons. In modern practice, however, fresh skimmed milk is ripened with a pure culture of lactic acid bacteria and makes a very agreeable drink of a smooth texture like that of fresh country buttermilk, though it is not so rich as the latter.

THE SUGAR SITUATION

THE sugar produced within the United States is about one-fourth of the total consumption which in 1920 amounted to 92 pounds per capita. The total estimated crop produced in the United States was 2,605,174,000 pounds, of which sugar from beets constituted all but 385,975,000 pounds.

In France a slow but constant progress is being made in re-establishing many of the plants destroyed during the war although it is not expected that all of the plants which were destroyed will be in production until 1925.

In Germany there were 269 sugar beet mills operating during the season 1919-1920 as compared with 307 in 1918-1919 season. Thirty of the 307 mills have passed out of German jurisdiction under the peace treaty. It is important that the beet production was the most available for many years due to weather conditions, improper cultivation of the crops, due to labor and strikes and the difficulties under which agriculture is pursued at the present time. The weight of the beets themselves was about one-half as compared with the preceding year and both the sugar content and purity were lower. The sugar produced amounted to 733,000 tons in 1919-1920, a little more than half that of the preceding year which meant that the production was under the domestic needs. Fortunately there was on hand something over 200,000 tons from the preceding year's crop. At this time Germany finds itself without available stocks on hand, but there is to be an increase in the cultivated area this year and fields are in better condition. The question still remains as to whether labor will be available and later fuel for the operation of the mills.

INDUSTRIAL ELECTROSMOSIS

A VERY interesting paper on this subject is controlled by Mr. F. Rowlinson to *Beama* for April, 1921. The author first reviews in a very clear way the phenomena of exosmosis endosmosis and osmotic pressure; this is followed by an explanation of colloidal state of matter and of the Brownian movements. The author then takes up the electrosmosis phenomenon. If a vessel divided into two compartments by a porous diaphragm be filled with water and that water be subjected to the action of an electric current from an anode and kathode immersed in each compartment, we shall see a migration of water through the diaphragm. The water passes from the anode compartment toward the kathode, and the level in the latter, therefore, rises. If clay be suspended in the water the clay particles will tend to migrate toward the anode. This action, discovered by Reuss in 1807, is termed electrosmosis, from its similarity to ordinary osmosis.

It remained for the German scientist, Count Schwerin to put these properties of matter to industrial use for the purpose of drying peat. The peat experimented upon was highly colloidal in nature and so slimy that although it contained 95 per cent of water, it would not pass through a 60-mesh sieve. Some of this colloidal peat was placed in a wooden sieve with an ordinary wire gauze bottom. On top of the peat an iron plate was placed to serve as one of the electrodes, the other electrode being the gauze of the sieve. As soon as the circuit was closed water immediately began to trickle through the lower gauze and the layer of peat decreased in thickness until it became a thin layer of friable dry material. Patents were taken out and Schwerin applied the process to the drying of peat on an industrial scale. Success was achieved as regards the practical part of the process, and a marketable product of drier peat was obtained. The cost, however, proved rather higher than anticipated, and the process was abandoned in Germany. The margin however was so small that a famous German scientific firm took up the process and spent huge sums in erecting a plant in Switzerland.

The next industrial application of electrosmosis was the purification of clay. The following is a description of an industrial plant for such purposes: The raw material dug from the earth is "blunged" with water and the necessary quantity of alkali and colloidal organic matter to give a differential charge to the clay and the impurities is added. The whole is run into a coarse settling tank to separate the very coarsest fragments of pyrites, dirt and sand. After this preliminary settling, a second may be necessary, or the material may be run straight off into the electrosmose machine. This consists of a wire-lined trough of wood, in which a metal drum slowly rotates. The wire lining of the trough constitutes the negative electrode, and the drum the positive. The clay slip runs in at one end and the excess overflows at the other. Clay begins to deposit on the drum immediately, and the deposit grows continually. Further, the clay deposit is very dry, notwithstanding the fact that it has been formed under the surface of the liquid. The impoverished slip, containing a certain proportion of clay (usually about 10 per cent) is allowed to overflow into a settlement tank, where the very finest impurities, rejected by the electrosmose machine, quickly settle now that the bulk of the clay has been removed. The supernatant liquor is used for a further lot of clay. Clay treated by this process is remarkably fine and plastic. It is used for the manufacture of the best quality ware and particularly for electrical insulation purposes.

A second recent application of electrosmosis is what is known as the Rogers-Bennett process for the extraction of oils from both animal and vegetable sources. In the case for example, of the extraction of oil from the livers of cod or other fish the electrical equipment consists of a steam jacketed steel box containing several (usually 20) sections of two-inch steel pipe. The pipes or "coils" are connected in series by insulating end-sections of rubber hose, so that there is a continuous passage through the whole of the unit by traversing each coil in turn. Down the center of each coil runs a one-inch diameter carbon rod, which forms the negative electrode; the coils themselves form the positive electrodes. Through the half-inch annular space between the positive and negative electrodes a macerated pulp of liver and salt water passes, circulated by a pump. The passage of the current across the salt water and pulp causes an electrosmotic pressure to be developed inside the fat cells. This pressure breaks down the protein envelope of the cells, and the oil contents are discharged. At least 99.5 per cent of the oil is thus set free. The pulp then passes on with its oil in the form of an emulsion, to a screen which separates the solid portions, while the oil and salt water pass on to centrifugal separators of the high-speed continuous type. The separated meal, or solid portion, is an excellent feed, or it may be used as a fertilizer.

Still other applications of electrosmosis to industrial processes on a large scale lies in the extraction of sugar from sugar beet, to new methods of tanning and in the petroleum industry. For each case the author briefly reviews the methods to be used.

Hydrogen from Steam—I

Commercial Processes Utilizing Steam in the Production of Hydrogen

By Harry L. Barnitz, Ph.G.

THE utilization of steam as one of the active reagents in the production of hydrogen is of utmost importance, as it is by its employment in commercial processes for the production of hydrogen, that the greater amount of hydrogen from steam for industry and war purposes is at present made.

Prior to the description of the processes utilizing steam in the commercial production of hydrogen it will be necessary to consider, in the first step, the manufacture of "blue water-gas" in which steam is one of the composite active reagents.

The three processes utilizing steam are:

The Iron Contract Process.

The Badische Process.

The Linde-Frank-Caro process.

All these are commercial processes and employ blue water gas.

PRODUCER GAS

Producer gas is a term which applies to any gaseous fuel obtained from solid fuel in a "gas producer," *i.e.*, coal or coke which is most generally employed and which can be nearly or completely consumed by means of partial oxidation and gives a combustible gas with no combustible residue. The oxygen required for the combustion of the solid coal or coke in making producer gas in actual practice is obtained from the air, from water or from both sources. Therefore, the three principal variations of producer gas may be distinguished as *air-gas*, *water-gas* and *semi-water-gas*, carbon monoxide (or carbonic oxide) CO, being the essential component of each of these gases.

Before describing the furnace required to produce the various gases, some information will be given concerning carbon monoxide. Carbon monoxide is always formed when carbon is burned in an insufficient supply of oxygen or air, but in this case, it is never pure, being always associated with carbon dioxide, thus:

$$2C + O_2 = 2CO$$

The reaction is reversible or takes place in two stages, thus:

$$2C + O_2 \rightleftarrows 2CO,$$

$$CO_2 + C \rightleftarrows 2CO$$

At 1,000 deg. cent. it is nearly complete in the sense of the upper arrow, while at 450 deg. cent. it is practically completely reversed.

Carbon monoxide is a colorless, odorless, tasteless gas which is 0.9672 times as heavy as air at and below 139.5 deg. cent. it may be condensed to a liquid by pressure. The critical pressure is 35.5 atmospheres. The liquid boils at 190 deg. cent. and the white, snow-like solid, formed, melts at 207 deg. cent. in the air and in oxygen; the gas burns with a rather small flame, forming carbon dioxide provided a trace of moisture is present, thus:

$$2CO + O_2 = 2CO_2$$

The above equation is indicated by exploding a mixture of carbon monoxide and oxygen, when two volumes of the former and one volume of the latter form two volumes of carbon dioxide. From this fact and the fact that 22.4 liters of carbon monoxide under standard conditions weighs 28 grains, it follows that the formula for the gas is CO. The result of the above experiment is only determined when the composition of carbon dioxide is known.

The heat liberated on combustion of carbon monoxide amounts to 68 calories per gram-molecule. The heat liberated from the formation of carbon monoxide from carbon being also exothermic is 29 calories per gram-molecule. Therefore, the thermic equation may be indicated thus:

$$2C + O_2 = 2CO + 58 \text{ cals.}$$

$$2CO + O_2 = 2CO_2 + 136 \text{ cals.}$$

and where combustion is complete

$$C + O_2 = CO_2 + 97 \text{ cals.} = \left(\frac{194}{2}\right)$$

It is evident, therefore, that about 30 per cent of the heat obtainable by complete combustion is evolved in the conversion of carbon into carbon monoxide.

Therefore the theoretical yield for 1 pound of carbon is

$$C \rightarrow CO \rightarrow CO_2$$

weight 1 lb. → 2 1/3 lbs. → 3 2/3 lbs.

Heat → 1,096 cals → 2.571 cals.

Total → 3.667 cals.

Carbon monoxide is a strong reducing agent. It is able to abstract oxygen from many metallic oxides at higher temperature and it may itself in turn be reduced by still stronger reducing agents.

Carbon monoxide is readily absorbed by an ammoniacal or hydrochloric acid solution of cuprous chloride. Carbon monoxide may be expelled from the solutions by heating. The acid solution of cuprous chloride is used in estimating carbon monoxide in gas analysis.

Carbon monoxide is a very poisonous gas and the fact that it is odorless makes it more so as it does not betray its presence till it has already produced toxic effects. The gas unites with the hemoglobin of the blood forming an addition product which is bright red in color and very stable. One-twentieth of one per cent. of carbon monoxide in air exerts toxic effects. Traces of the gas may be detected by shaking the suspected air (after freeing, if present, from ammonia and sulphuretted hydrogen) with a solution of palladium chloride 0.05 per cent which is sufficient to produce a precipitate. Cases of carbon monoxide poisoning should be treated by removing the patient into warm, fresh air, application of warm artificial respiration, and the administration of oxygen under a pressure of one to two atmospheres. Medical aid should be sought.

PRODUCERS

It is not the author's object to treat in detail the subject of producers, but to give only a general outline sufficient to make clear the mode of action of producers as an adjunct to the production of hydrogen. There are many types of producers and various extended uses. A producer lends itself to the utilization of a great variety of fuels. The temperature and economy obtained depend to a great extent on the design of the furnace and burners and type of grate used and the manner in which the air blast is admitted. The chief aim of modern producers is to effect the various stages of gas production by mechanical means as far as possible, and thus render the whole process continuous.

Gas producers are known as *wet* and *dry*, but they are all worked on practically the same principle.

AIR GAS

In a dry producer, coke—coal or other suitable fuel—is carried on a grate surmounted by a brick-lined cylinder of steel plate, on the top of which is a hopper or fuel feeding box. Air is blown by a fan under the grate, which is also enclosed in the outer casting. It converts the fuel (*i.e.*, coal or coke) on the grate into CO_2, and heats that above it to an incandescent temperature.

The CO_2 which rises through this hot fuel on its way to the outlet pipe absorbs a second atom of carbon, and the result is thus expressed:

$$CO_2 + C = 2CO,$$

carbon monoxide being formed as shown in Fig. 1.

When such an apparatus is worked with air blast only the resulting gaseous fuel is known as air gas. The amount of air supplied must not, of course, be sufficient to oxidize the fuel to the fullest extent, since what is aimed at is the production of the maximum amount of carbon monoxide, and the minimum amount of carbon dioxide.

Naturally the composition of air gas will depend on the material of the fuel employed. An ideal gas obtained from pure air and carbon would consist, by volume, of carbon monoxide, 34.7 per cent and nitrogen, 65.3 per cent. However, in actual practice it is impossible to avoid a small percentage of carbon dioxide and if coal is used (not coke) a small amount of methane (which is valuable as a fuel) is always present owing to the distillation of the coal on the top layers in the producer.

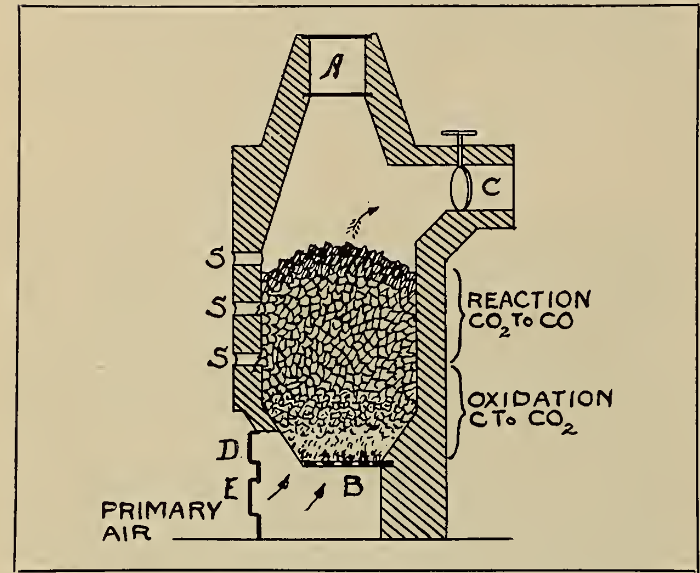


FIG. 1. SECTION THROUGH A PRODUCER

Hot air entering at *E*, and passing through the fire-bars, burns mainly to carbon dioxide in the lower part of the furnace, then passing through the upper layers of red-hot fuel, it takes up more carbon and is reduced to monoxide. The resulting air-gas passes through the exit *C*. *A* is the charging-hopper for fuel, *SSS* are holes for poking, etc., and *D* is a door for cleaning the fire-bars

The following is the usual analysis of air gas:

	COAL No. 1 % by Volume	COKE No. 2 % by Volume
Hydrogen	5.35	1.0
Carbon Monoxide	29.0	32.6
Methane	2.05	....
Total Combustible Gases	36.4	33.6
Carbon Dioxide	2.0	1.4
Nitrogen	61.6	65.0
Total Incombustible Gases	63.6	66.4
Calorific Power, B.T.U. per cubic foot	130.8-138.7	114.5-115.0

Air gas is used for same purposes as semi-water gas, but is considerably less employed as it is by no means as economical.

WATER GAS

Water gas, also termed "blue water gas," is the most important of the varieties of producer production gases, so far as its relation is concerned in the generation of hydrogen.

In the manufacture of water gas, the oxygen required for the combustion of the solid fuel is obtained, not from the air *but from steam*. The fuel is burned by air to a high degree of incandescence, and the gas is sent to waste, *steam* is then sent without air through the hot fuel and the resultant gas is almost wholly combustible.

In the production of this gas no carbon dioxide (CO_2) is intended to be formed, but a slight amount gets through the gaps in the fuel unconverted. Nor should there be any free oxygen in the gases produced. Where the fuel is of considerable depth the burden in the producer is heavy, and the fuel becomes better consolidated and free from caves, and less carbon dioxide (CO_2) and nitrogen (N_2) get through unconverted. The reacting materials should be maintained at a temperature not below 1,000 deg. cent. in order to prevent the formation of more than a negligible proportion of carbon dioxide in the manufacture of water gas.

Ideal water gas should consist of 50 per cent. of carbon monoxide and 50 per cent. of hydrogen by volume. However, in actual practice small amounts of carbon dioxide and nitrogen cannot be avoided. Water gas has the following average composition:

	Volumes.
Hydrogen	49.0 per cent
Carbon Monoxide	43.0 per cent
Methane	0.5 per cent
Total Combustible Gases	92.5 per cent
Carbon Dioxide	4.0 per cent
Nitrogen	3.5 per cent
Total Incombustible Gases	7.5 per cent
Combustible and Incombustible Gases	100 per cent
Calorific power, B. T. U. per cubic foot	290 to 340 per cent

This gas is particularly applicable to high flame temperature and furnace work, especially in reduction of oxides and where a reducing flame is desired.

The efficiency of the generating apparatus of a water gas outfit is about 80 per cent. The generator requires auxiliary apparatus to furnish steam and air for the generation of the gas. Including this fuel, the overall efficiency of the plant is about 61 per cent.

SEMI-WATER GAS

Semi-water-gas is what is generally termed "producer gas" and is always understood to be such when the term is thus employed. It is produced by blowing steam and air simultaneously through red hot coal, coke or other carbonaceous fuel in a type of gas producer such as shown in Fig. 2, employing the same producers as that in which "blue water gas" is made —the difference being in mode of operation.

Ideal producer gas in theory is expressed by the following equation:

$$2C + O = 2CO,$$
$$\text{and } C + H_2O = CO + H_2,$$

and would have the following composition by volume:

Carbon Monoxide	39.9 per cent
Hydrogen	17.0 per cent
Nitrogen	43.1 per cent

whereas in actual practice the gas from the following typical analysis by Sexton shows considerable variation in samples of producer gas:

ANALYSIS OF SEMI-WATER GAS

	No. 1 %	No. 2 %	No. 3 %	No. 4 %	No. 5 %
Hydrogen	8.60	12.13	10.90	19.43	12.60
Carbon Monoxide	24.40	26.40	27.00	16.15	20.40
Methane	2.40	2.00	1.28	2.66	3.50
Carbon Dioxide	2.20	9.16	4.50	11.53	5.50
Nitrogen	59.40	50.31	56.32	50.23	58.00

Semi-water-gas is employed for many purposes in furnaces for tempering and annealing steel, melting brass, copper and aluminum, soldering, drying, japanning and in the baking of enamel on metal. In this work the gas need be neither cooled nor scrubbed clean. It also is employed to a great extent as power for gas engines. Semi-water-gas lends itself admirably to metallurgical work, as with the gas an oxidizing or reducing flame may be obtained as desired. It contains more hydrogen and carbon dioxide and less carbon monoxide and therefore a smaller calorific power. It is more economical than air-gas and is used far more extensively. Under certain modifications of method in producing semi-water-gas it is possible to recover the nitrogen of nitrogen-containing fuels, as ammonia.

PURIFICATION OF THE BLUE WATER-GAS

It is necessary to purify the crude water gas used in the production of hydrogen. The water-gas should be freed from the impurities which it mechanically contains, such as ash and dust, carried by the gas from the producer.

To remove the mechanical retained impurities, the water-gas is passed up through a tower, down which water is falling—this is termed, scrubbing the gas with water. This water scrubbing removes the mechanical retained impurities and, at the same time, reduces the temperature of the gas and causes the condensation and removal of the small quantity of iron carbonyl in the gas.

The removal of sulphuretted hydrogen from the water gas, which is necessary, is ordinarily accomplished by passing the gas at about 55°-65° F. over hydrated oxide of iron, contained in rectangular steel boxes, with the following reaction:

$$Fe_2(OH)_6 + 3H_2S = 2FeS + 6H2O + S$$

In the course of time, the hydrated ferric oxide ceases to absorb and is then directed through other hydrated oxide. The spent oxide is removed, moistened with water and exposed in the open air for revivication and after this treatment is again ready for use. Each revivification increases the free sulphur content approximately 7 per cent and with continuous revivification, the iron oxide increases to 50-60 per cent sulphur. Approximately 1 ton of oxide will purify 2,000,000 cubic feet of gas before it is finally spent. In practice 100 tons of hydrated ferric oxide will purify 200,000 cubic feet of crude water-gas per 24 hours—allowing a reserve of 25-30 tons "revivified" oxide.

In winter, where the temperature is low, it is necessary to provide the purifiers with steam coils, otherwise no absorption of sulphuretted hydrogen takes place, owing to the fact that water is produced which freezes on the surface of the hydrated ferric oxide, and prevents further sulphuretted hydrogen from coming in contact with it.

To prevent back pressure due to packing or caking of the ferric oxide, 15 per cent of water by weight is usually added and either sawdust, approximately 1 part to 5 of oxide by volume, or some spent oxide (containing considerable free sulphur) is mixed with the new oxide. To keep the oxide alkaline, usually 1 per cent of lime is added.

PRODUCTION OF HYDROGEN BY THE IRON CONTACT METHOD

One of the methods that has found favor in recent years for the production of hydrogen in installations of large commercial capacity is the so-called "iron contact method." It is by this method that the greater amount of the world production of hydrogen for use in industry and war is at present made.

The generating elements employed by this method are coke and water, and through them hydrogen can be produced of almost "chemical purity," *i.e.*, of a purer grade than by many other technical processes for large production excepting the electrolytical.

The iron contact method is cyclic with respect to the "iron contact mass"; that is, this iron contact mass is used over and over again. If red hot iron is sprayed with a jet of steam, the iron is oxidized and forms iron oxide, while hydrogen is liberated. If the iron oxide thus produced is treated with reducing gases, such as generator gas, water-gas or illuminating gas, the iron oxide is reconverted into sponge iron.

All these reducing gases consist chiefly of a mixture in varying quantities of carbonic oxide, hydrogen and hydrocarbons.

In practice blue water-gas is now used exclusively in reduction—as such a gas rich in hydrogen greatly accelerates the process of reduction.

The reactions used in the iron contact process may be represented by the following formulæ:

(1) Oxidation: $Fe + H_2O = FeO + H_2$.

(2) Reduction: $2FeO + H_2 + CO = 2Fe + H_2O + CO_2$.

It will be observed that equation (2) is exactly the reverse of equation (1) at least as far as steam is concerned.

The reaction takes place at the surface of the "contact mass." Only where the fresh gases enter, a powerful and far-reaching reaction generally takes place, while the reaction generally decreases in intensity in the direction of the outlet of the gas.

Compact iron, such as waste or filings, is little suited as a contact substance for the process, but iron oxide, either artificial or natural, *e.g.*, iron oxide clay briquets or iron ore, are suitable, but preferably to be recommended is calcined spathic iron, the purest form in which ferrous carbonate ($FeCO_3$) occurs in nature. All these substances become more or less porous during the reducing process.

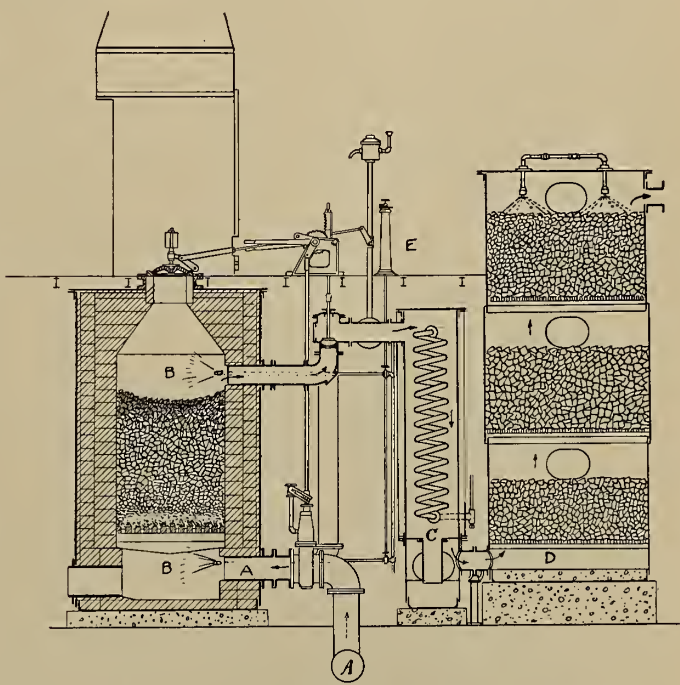


FIG. 2. BLUE WATER-GAS APPARATUS WITH OPERATING FLOOR

A, air blast; *B*, steam supply; *C*, cooler; *D*, scrubber; *E*, operating floor

Theoretically speaking, the contact mass could be used over and over again indefinitely in accordance with the before mentioned formulæ so that an unlimited quantity of hydrogen could be produced by means of a limited quantity of contact mass.

In practice, however, a limit is placed to the life of the contact mass by the fact that as it is only the surface of the latter that is being acted on. The substance gradually becomes impregnated by the dust, silicic acid and sulphides liberated by the gases. These impurities form a layer on the surface, diminishing the reacting capacity, so that the yield of hydrogen

is gradually lowered and other disadvantageous combinations take place.

It is necessary, therefore, to renew the contact mass periodically, say after the plant has been in operation for from 8 to 30 days.

The principal difficulty with the iron contact method arises from the fact that a considerable amount of heat is absorbed during the various stages of the process by the chemical reaction. It is therefore not easy to keep the contact mass at a correct temperature without overheating. If overheated, the contact mass loses its porosity, cakes and even melts. This renders the replacing of the contact mass difficult or even impossible. The action of the gases becomes defective and the yield of hydrogen falls considerably, as channels and cavities are formed which can no longer be acted upon regularly by the gas and steam.

As the iron contact method is very old, all kinds of suggestions have been made in the course of time in connection with the practical method of dealing with this process. A voluminous mass of patent literature on this subject is in existence. Only the most important of these patents, most of which have long ago expired, are here passed under review.

Giffard, who made the method public in 1878, may be considered the discoverer of the method. He employed a shaft filled with ore which he heated and reduced by means of gases coming from a producer connected with the shaft and which passed through a dust chamber, in order to remove the particles of dust introduced during the operation. The defect of this system was that the ore was easily contaminated by the impurities contained in the gases and that a sufficiently high temperature could not be maintained.

In 1889 Claus (English Patent No. 50) published a method for the production of hydrogen in a shaft furnace. He, too, employed "porous though solid blocks of iron oxide" which he alternately reduced with water gas and oxidized by means of superheated steam.

Walker's English patent No. 8373, dated 1890, describes the operation of the contact method in iron retorts, which were heated in a retort furnace from the outside. He employed water gas for the reduction.

In 1892, the firm of Krupp published various improvements of the process (D. R. P. No. 73978) which, however, did not produce satisfactory results and were ultimately rejected.

Iron ores were employed in heated shafts or retorts and attention was drawn to the importance of employing reducing gases as rich as possible in hydrogen with a minimum of hydrocarbon.

Stracke returned in 1893 to the Giffard shaft furnaces (German Patent No. 77,350) and filled a shaft furnace with layers of "iron, iron oxide and ore in any form," heating and reducing the whole by heated generator gas or water gas which he introduced through the ore from the generator. He used charcoal in the generator in order to avoid the formation of sulphur compounds while producing exceptionally pure gas. The waste gases formed during the process of reduction were completely consumed in a superheater with fireproof cage-work which served to raise to a high temperature the steam used in producing the hydrogen. Here too the heating was insufficient.

Schimming took out a German patent, No. 95,071, for the preliminary heating of the reducing gases which he achieved by blowing air into the reducing shaft in order to cause combustion of a portion of the reducing gas. This method had the grave defect of over-heating and melting the ore at the entrance, while the ore further away was not sufficiently heated. He tried to remedy this defect by mixing pieces of fire brick with the contact mass in order that the former might retain a portion of the heat, but the system involved serious drawbacks.

Caro, in German Patent No. 249,269, tried to overcome the want of uniformity in the heating by introducing air to the ore mass at various points during the reducing process. It is evident that under this system the reducing capacity of the gases was seriously affected, so that the yield of hydrogen was altogether too low.

Lewes's English patents, No. 4134 and No. 20752, dated 1890 and 1891, once more describe the iron contact method in detail. He proposed to lay a retort with iron contact mass directly through a water gas generator, which was technically hopeless owing to the consequent overheating. He proposed for the first time to employ porous briquets made of iron oxide and clay or asbestos and then pressed and burned. He employed water-gas for reducing, justly pointing out that the use of such gas rich in hydrogen greatly accelerated the process of reduction.

Hills describes in his English Patent, No. 10,356, dated 1903, the production of hydrogen by the iron contact method which he proposes to carry out in iron retorts. Unimportant improvements in the apparatus employed in the already well known process were patented by him. He used water-gas for the reducing process.

Elworthy, in German Patent No. 64,721, dated 1905, discusses the contact method exhaustively. He notes as the chief defects the tendency of the mass to melt and the choking of the retorts. He proposes to overcome this difficulty by using furnaces in which the spongy iron is contained in specially constructed fire-clay holders. The use of iron in lumps of varying size is taken for granted. By "iron" he always means spongy iron, produced by reduction from iron oxide or iron ore, as, he explicitly states in his English Patent No. 12,461, dated 1902. He employs water-gas for the reducing process.

Lane constructed installations in Russia, France and England about 14 to 16 years ago on the iron contact method. He used chiefly briquets similar to those suggested by Lewes, made of iron oxide and clay which were reduced by water-gas in iron retorts, in large iron retort furnaces. The installations proved, however, to be of inferior working capacity as in the case of the proposals made by Walker (1890) and Hills (1903).

The International Hydrogen Company, whose shares are held by the Berlin Anhalt Machine Construction Company of Berlin, thereupon duplicated the identical method. The result was the same as in all other previous cases.

The inevitable difficulty of the retort system lies in the fact that the retorts are destroyed by fire after being a short time in operation besides being choked by the ore.

Heating of the retort furnaces entails the use of a special system of coke firing, built in the retort furnaces, and involves the use of a considerable amount of coke (about 1,200 to 1,500 kilos per furnace daily). The latest designed (1917) retort generator employs blue water-gas for heating the retorts.

The oldest system employed by Giffard, already referred to, undoubtedly possessed important advantages over this system, but the difficulty of heating was a very serious one as is shown by the above mentioned extracts from the patent literature on the subject. Recently, however, after exhaustive experiments, many of the difficulties connected with the rational carrying out of the iron contact method in large industrial plants have been to a great extent overcome, such as rapidity in getting the plant into working order, more certainty of operation, and simplicity.

Giffard suggested ore as a contact mass. When properly treated, specular iron ore, red hematite and iron oxide hydrates have generally been found suitable. The use of purple ore was protected by Patent No. 220,889 and that of sparry iron ore by Patent No. 241,669 (dated 1911). The former has the disadvantage of containing too much sulphur and cakes easily, while the latter often melts too easily.

Their use, therefore, offers no advantages. As a rule briquets act too slowly, owing to their defective porosity.

According to German Patent No. 244,732, taken out by the International Hydrogen Company, spongy iron free from carbon can only be produced by reduction and out of it pure hydrogen, when instead of the usual water gas, a gas con-

sisting chiefly of hydrogen, but absolutely free from hydrocarbons, is employed. In practice this assertion has not been found to be warranted, as there exist no practical methods of producing such a gas.

The Badische Aniline & Soda Manufacturing Company has admitted in a recently announced patent that spongy iron produced by a reduction from iron ore by means of coal in Sweden for smelting purposes is suitable for the preparation of hydrogen. Experts have long been aware that the maintenance of a proper temperature is indispensable for the production of spongy iron free from carbon. If this is done, any reducing gas, even pure carbonic oxide, may be used for reducing, but water gas has the advantage of acting more quickly, as has been decided by experts who investigated the matter several decades ago.

(*To be continued*)

Tetralin and Dekalin

A New Illuminant, A New Lubricant and a New Source of Synthetic Drugs

THE once rejected coal tar which has become a veritable Aladdin's cave of riches has by no means exhausted its possibilities of benefit to mankind. One of its well-known products is naphthaline, which is readily separated from the "heavy oil" fraction because of the ease with which it can be crystallized. On this account undesirably large quantities of this product tend to collect in coal tar works and are not readily salable in spite of its very low price. While it is true that naphthaline has long been employed in the dye industry, especially for making the so-called nitro dyestuffs as well as artificial indigo, these industries do not suffice to absorb the whole product. Naphthaline has been used also for making lamp black, but this is hardly to be considered a highly economical employment.

Early during the Great War a German professor, mindful of these things, succeeded in working out a commercial process based upon earlier laboratory experiments by means of which naphthaline is united with hydrogen to form fluid substances of peculiar nature and exhibiting commercially valuable properties. While, as we have said, these "hydration projects" of naphthaline had already been prepared by laboratory methods, these were both tedious and costly; German industry has found itself greatly indebted, therefore, to professor, Dr. G. Schroeter, for finding a capital solution of the problem. This problem consisted technically in uniting the hydrogen which is produced by a well-known process from water and coke according to the equation:

$$C + 2H_2O = CO_2 + 2H_2$$

Carbon plus water equals carbon-dioxide plus hydrogen, in as continuous a process as possible with the naphthaline. This problem had already been partly solved in the industrial process in which liquid oils are hardened by the addition of hydrogen so as to be available for solidifying tallow for the purpose of making soap and oleomargarine; in this process substances called "hydrogen-catalyzers" are employed for the carrying over of the hydrogen. These possess the property of forming loose compounds with hydrogen, somewhat comparable to metal alloys, and thereby they cause the hydrogen to become "active," *i.e.*, capable of chemical reaction. Only small quantities of these catalyzers are required since the "alloyed" hydrogen begins at once to be given up to the substances undergoing hydration, so that the catalyzer is continuously available for forming the pseudo-alloy with new quantities of hydrogen. But the application of this process to naphthaline offers difficulties; the technical form of naphthaline is not capable in fact of such a catalytic absorption of hydrogen without previous preparation; it must also in its turn be "activated" by preliminary treatment and, of course, the process by which this is done must be neither costly nor complex.

It was found by experiment that what is known commercially as "warm pressed stock," *i.e.*, crude naphthaline compressed while still warm into cakes (a form which can be shipped by rail without packing) can be "activated" or "detoxified" sufficiently for the purpose in question by fusing it and stirring it up with small quantities of very finely divided or else readily fusible metals, such as sodium, potassium, etc., and then distilling under lowered pressure. Naphthaline prepared in this manner is united while still in a fused condition with hydrogen, by means of catalyzers in a continuously carried on process, within compression vats; in this manner it is changed into the desired hydro-naphthaline, and the latter is then distilled in a vacuum. The resultant products are divided according to the number of hydrogen atoms taken up by the naphthaline during the process of hydration into tetra-hydro-naphthaline, known in brief as *tetralin* and deka-hydro-naphthaline (dekalin for short) both of which can be produced in the prescribed manner without loss and at a very moderate cost.

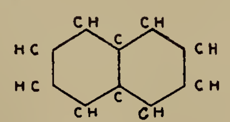
Simple as these processes appear to be, many difficulties were found in adapting them to use on a large commercial scale, particularly in the present economically difficult times; the credit for this placing of the matter on a commercial basis belongs to the Tetralin Company, especially to Mr. H. V. Gwinner and Mr. W. Schrauth, who have carried out the technical arrangements for putting the Schroeter process in technical operation and now have in commission a large plant capable of turning out about 100,000 kg. of this liquid hydronaphthaline per day.

Tetralin and dekalin are colorless, readily flowing fluids having a boiling point of 260° C. or 189° C.; they have a lower specific gravity than water (D^{20}=0.97 or 0.89); they can be employed as a form of fuel, *e.g.*, in "tetralin-cookers," or to drive motors, in which case they are mixed with benzine.

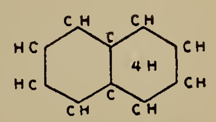
Dekalin can be burned in any perfectly clean kerosene lamp and yields a bright flame without either smoke or odor, and one which is not only economical but also quite safe, since the ignition point of dekalin is very high.

Both tetralin and dekalin are extremely useful as solvents for resins, oils, etc., thus furnishing economical substitutes for imported products.

Chemical transformations of tetralin and dekalin.—According to the chemical formula assumed for the naphthaline molecule ($C_{10}H_8$) its structure may be represented by two rings each of which contains six members consisting of carbon atoms, but with two members in each ring common to both these, so that a "twin nucleus" is formed in which each of the two parts has the chemical character of a benzene-nucleus. By the introduction of 4 hydrogen (H) atoms into one of these nuclei, however, the latter is deprived of its "benzene character," while its "twin sister" appears still to cling to its original chemical character, corresponding to the formula.



Naphthalin.



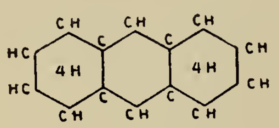
Tetralin.

We have been obliged recently, however, to somewhat modify this original concept of the tetra-hydro-naphthalin formula, it is true, but in a certain measure it still holds good. The

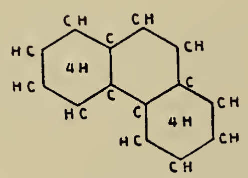
benzene character is expressed particularly in the fact that the benzene nucleus readily unites with nitric acid and with sulphuric acid in such a manner that "residues" of the nitric acid and the sulphuric acid are formed, and from these "intermediate products" there are produced, through further transformation, those medicines, dyestuffs, perfumes, and explosives, which were indicated in the beginning by the reference to benzene and toluol. Thus we see that tetralin also may be looked upon as a source of many substances of this kind.

But the hydrated "twin sister" has also acquired peculiar characters; one of the ways in which this is revealed to us is the manner in which it acts in the body of a dog. Considerable quantities of tetralin can be absorbed by a dog without injury to its organism; the latter does not excrete the tetralin as such; the tetralin is first transformed through the absorption of oxygen by the hydrated nucleus, into an alcohol, and this alcohol is partly transformed in its turn by combination with the urea of the body into a *tetralin-urea*. This observation led to the further one that besides the oxygen in the body of an animal suitable "transmitters" are capable of readily transforming the tetralin into an oxidation product—the so-called "tetralon"; this new product is formed by the substitution of one oxygen atom for 2 hydrogen atoms in the hydrated nucleus; this substitution also makes the hydrated nucleus highly capable of reaction, but this in a manner quite different from that of the non-hydrated nucleus—and we can here obtain a new series of "intermediate products" which promise to be valuable from the technical point of view.

Let us close this brief account of these remarkable and valuable new products by the following observations: When the chlorine compound consisting of a combination of Cl with the metal aluminum (Al), *i.e.*, aluminum chloride is added to tetralin in small quantities at a moderate temperature and the mixture well stirred, then the hydrated twin nucleus will be severed, benzene will be formed by the isolation of the non-hydrated nucleus, and the split off hydrated portion of the nucleus will attach itself to other tetralin molecules, thus forming "triplet-nuclei," to which we have given the names "octhacene" and "octantrene," because of the fact that they are formed from the anthracene and the phenantrene of the coal tar by the taking up of 8 (octo) hydrogen atoms.



OCTHRACEN



OCTANTREN

These hydrated triplet-nuclei are related to many plant alkaloids of great medicinal value, especially to those of the opium group, such as morphine and codeine, so that we are justified in cherishing the hope that these easily obtainable substances may form the starting point for the production of certain synthetic medicines—so that the chemistry of these "aromtic" hydro-products seems destined to add to the treasures of pharmaceutical products.

From this point of view let us recall the peculiar behavior, noted above, of tetralin in the body of a dog, and mention, in addition to this, the long-known effects—both mydriatic and toxic—of the ac. β-amino-tetralin, which contains the ammonia-residue in the hydrated part of the nucleus. We have further succeeded in demonstrating that *the phenols of the tetralin series surpass all other phenols in their powers of disinfection;* an admirable proof of this is found in the fact that they are capable of destroying, even when applied in the form of a very dilute solution, the highly resistant spores of anthrax, and this in a very short time.

Dekalin, too, in which both parts of the nucleus of the naphthaline are completely saturated with hydrogen, is susceptible of undergoing peculiar chemical transformations—however, the paths of investigation along this line are opening but slowly before the chemist; at any rate we believe we have proved our thesis as to the economic and scientific interest which attaches to the naphthaline hydrogen compounds.

DUST EXPLOSIONS

It has become well known that a wide variety of dusts will explode if ignited by flame or spark under favorable conditions, particularly where the right mixture of dust with air obtains. An explosion of hard rubber dust recently occurred in which eight men were killed and considerable property damage done. The Bureau of Chemistry has made an investigation of this accident which is discussed in detail in the April 27th number of *Chemical and Metallurgical Engineering* and the investigators take occasion to emphasize the following precautions to be taken in hard rubber grinding:

"1. The grinding department should be segregated from the remainder of the plant and if possible operated independently of other units.

"2. The building containing the grinding department should be of heavy framework with light walls and roof so as readily to permit the release of pressure from the building should an explosion occur. Large window area serves this purpose very well and the modern daylight construction is recommended.

"3. Good ventilation should be provided and where gases heavier than air are produced during the process the air should be drawn out of the room near the floor and fresh air admitted near the ceiling or roof.

"4. Where fine dust is produced during the process an efficient dust-collecting system should be installed. The old-style dust room, where large clouds of dust are in suspension, should be eliminated if possible or located at a safe distance from the main building. The dust should be collected as near as possible to the point of origin and conveyed through pipes with as few turns as possible to the collector, which should be located outside of the building or vented to the outside air. If sharp turns are necessary in the pipe line inside the building, it is often advisable to provide a vent at the bend leading to the outside air with a cap which will be blown off should any high pressure occur at this point. Drawing explosive dusts through a fan should be avoided if possible. A suction through the collector or an induced-air current is preferable.

"5. Special precautions must be taken to see that no metal enters the grinding machines. This is the only way to guard against ignition of dust by sparks struck in the machines. A vent leading directly from the machine to the outside air often assists in preventing a disastrous explosion by providing a direct means of escape for the primary explosion within the machine.

"6. In places where clouds of explosive dusts are produced electric lights should be enclosed in vapor-proof globes and properly guarded to prevent accidental breakage. All switches and fuses or electrical equipment in which sparks might be produced should be located in a separate room or at least enclosed in fireproof and dustproof boxes.

"7. Rules against smoking and carrying matches in sections of a plant where conditions are favorable for a dust explosion must be rigidly enforced and special attention given to the prevention of hot boxes on machinery operating in dusty atmospheres.

"8. Cleanliness is the best general precaution to adopt for the prevention of dust explosions. A disastrous dust explosion cannot occur in a clean plant, because the flames cannot propagate unless dust is present to be mixed with the air in sufficient quantity. From 0.02 to 0.04 oz. of dust per cu. ft. of air is usually sufficient to form an explosive mixture. The plant should be kept scrupulously clean, especially overhead structures where dust accumulations could be thrown into suspension in the air by a sudden jar or shock."

Steel Direct from the Ore

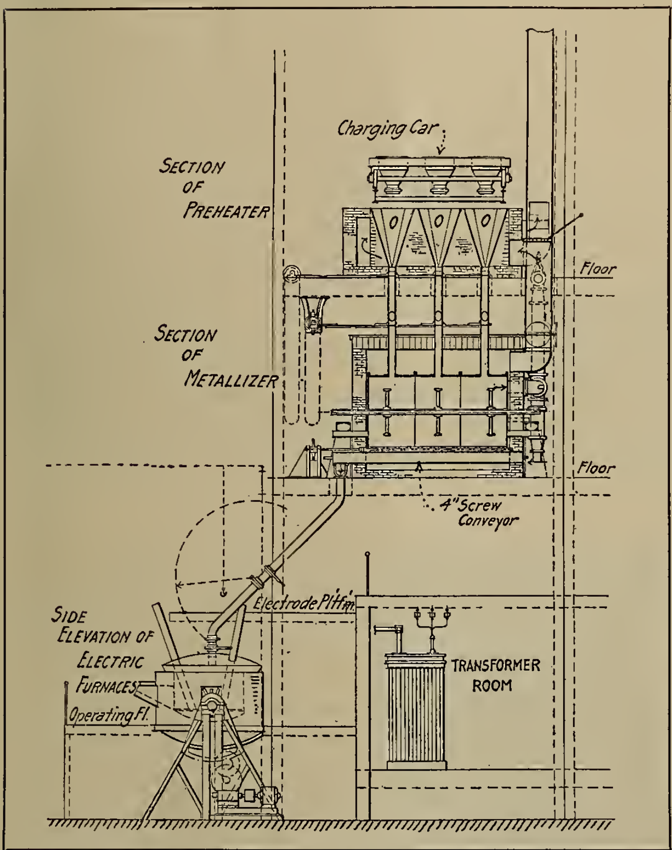
Recent Attempts at Producing Steel Without the Intervention of the Blast Furnace

By Edwin F. Cone

FREQUENTLY there have appeared in the public and technical press in the past rather sensational articles on the production of steel direct from iron ore. Within the last month or so this subject has again been brought to the front by a cablegram from France to the *New York Times* making striking claims for a new process of this nature, known as the Basset. It has elicited comment from metallurgists and technical papers and has created considerable interest.

At the outset it may be stated that thus far in the history of this movement none of the suggested processes has reached the successful commercial stage. This is not to say that some of them will not, for he is a rash prophet who predicts the failure of projects that now seem revolutionary.

In the first place it is well to explain what is meant by the term "steel direct from the ore." According to present world-wide practice, iron ore is first converted into pig iron in what is familiarly known as the blast furnace. This is initially an expensive apparatus costing several million dollars when installed on the present American scale; that is, a furnace which will produce 600 tons of pig iron per day.



SECTION OF THE METALLIZER THROUGH THE IRON ORE RETORTS AND THE MECHANISM FOR DELIVERING THE IRON SPONGE TO THE ELECTRIC FURNACES

In such a furnace the iron ore is mixed with lime stone and with a high grade of coke. The smelting operation by means of a blast of hot air under pressure converts the iron ore into iron; that is, the carbon of the coke eliminates or burns out the oxygen of the ore and the result is iron containing dissolved carbon to the extent of 3 to 4 per cent and other elements. This is the commercial pig iron of to-day as made in all large producing countries. After the first installation of the blast furnace, the process is not an expensive one. It depends of course on the ability to obtain a good coking coal within reasonable distance of the iron ore. This process has become firmly entrenched in America and Europe.

The dream of metallurgists and inventors has been to devise a process whereby the making of pig iron in a blast furnace could be eliminated and the ore converted directly into steel. To make steel by present practice, it is necessary to convert the blast furnace pig iron, in the cold or hot condition, into steel in a separate furnace. The plan as worked on by inventors has been to reduce the iron ore to iron in one apparatus and then to convert this iron into steel either in the same apparatus or in an additional furnace. The former is known as the one-step direct process and the other as the two-step direct process. The advantage of a successful direct process, aside from the expense, would be the doing away with the use of coke and the use in its stead of any grade of coal as a fuel. Such a successful process would make its use a great boon to such countries as Sweden, Norway, Canada and Brazil where the ores are plentiful and of high grade, but where there is very little coal suitable for blast furnace operations.

With this object in view there have been several processes of direct conversion put forth but none of them as yet successful commercially unless it be the French Basset process already referred to. The fault cannot be said to lie entirely in the process as devised. So much pig iron is cheaply made by the present blast furnace that this has tended to smother the success of the new ideas.

One of the less recent processes of a direct nature is the Jones, an American process. This has been characterized by one American electrochemist as "antiquated and imperfect" and that "to compare it with the Basset is like confounding night and day." The Jones process is a step process in that there is more than one step involved before steel is produced.

Another process, patented in the United States and in foreign countries in 1920, is the Lang. A description of this process appeared in *The Iron Age*, May 12, 1921. In this process ore is mixed with coal, both powdered, and the mixture placed in metal shells. These fall slowly down a long reverberatory furnace and the gases heat and reduce the ore in the shells which then fall into a special receptacle where the reduced iron, shell and all, is melted. The final purification is done in another furnace, probably electric. This process is being installed at a plant in Santa Cruz, Cal., by the Direct Process Steel Co., Inc. The future will reveal its practicability. In California coke is scarce and some such process as that or the electric is much desired.

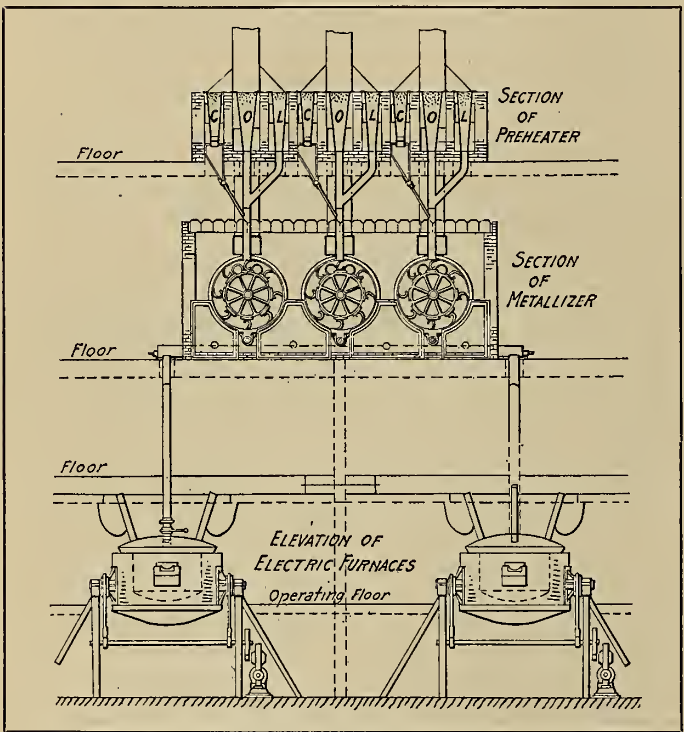
One of the latest, prior to the Basset, which American metallurgists have investigated, is the Bourcoud. This is a very elaborately calculated process for direct conversion in which large revolving cylinders, like cement kilns, are used where the theoretical amount of fuel and gases are brought in contact with the fine ore and, it is clamed, complete reduction is obtained. The reduced iron is then refined and converted into steel in electric furnaces. The process is completely described in a recent issue of *Iron and Steel* of Canada, but as far as known it has not been used anywhere commercially.

The Basset process, about which so much has been said recently, was first referred to in this country in *The Iron Age*, September 9, 1920, but details were lacking at that time. According to the reports from France which have recently been made public, this process uses powdered coal and iron ore mixed and the grade of coal need not be of the best. The oxygen necessary for ignition is introduced as a blast of hot air preheated to about 1,000 deg. cent. This heated air

is also mixed with powdered coal. The combined result of the combustion is stated to be a temperature far beyond the fusion point of the reduced metal and slag which, it is claimed, results in the product's being withdrawn from the furnace as molten steel. It is really a one-step process. Reports from Paris are that it is in successful commercial operation in France. An American electrochemist has said recently that "it does not seem likely that it will have general or extended application without considerable modification in practice."

Of interest at this time is a German opinion of the Basset process. At a meeting of the German Iron Masters' Association last winter an address was delivered by Doctor Wüst, director Kaizer-Wilhelm Institute for Iron Research at Düsseldorf, Germany, on the process of direct smelting of iron ore into steel. His remarks, as reported by the London *Ironmonger*, were as follows:

He traced the development of the various iron-making processes, and referred to the Basset direct smelting process, of which there has been so much talk lately and which claims to be able to produce iron 70 per cent cheaper than it can be made in the blast furnace, and to save 80 per cent in the cost of installing the plant. Dr. Wüst showed by temperature calculations that a revolving furnace under the Basset process could turn out only one-fifth of the iron produced by a blast furnace of the small capacity in the same time, and declared that the new process was not at all likely to replace the present indirect method.



GENERAL ARRANGEMENT OF THE REDUCING FURNACE OF THREE RETORTS AND THE ELEVATION OF THE TWO ELECTRIC FURNACES

Our next door neighbors, the Canadians, claim credit for a direct process which has been known for some time in its earlier stages. It is the one developed by J. W. Moffat of Toronto, Canada, and originally introduced at the Moffat-Irving Steel Co. There for some years steel was made direct from ore in a small way, but it never developed on a large scale. Possibly expense of operation or the necessity for improvements were the reasons.

At any rate within the last year or two Mr. Moffat has decidedly changed his original methods and has developed a steel-direct-from-the-ore process which bears his name and which has been described in detail in several technical papers. The latest one appeared in *The Iron Age*, June 2, 1921, while others were published in *Iron and Steel of Canada* in October, 1920, and in the *Canadian Mining Journal*.

Briefly the Moffat process uses a special furnace called a metallizer in which the ore is reduced to metallic iron or iron sponge by the use of coal and lime, the three materials being pre-heated in a pre-heater. The metallizer contains a rabbling apparatus which keeps the material constantly agitated, lifting the ore particles and exposing them many times to the reducing gases. The metallizer product or iron sponge then falls down on an air-tight conveyor which delivers it to one of two electric furnaces where it is converted immediately into steel by refining out the impurities and adding such materials or alloys to make the kind of steel desired. The illustrations show quite clearly the Moffat process which is typical of most of these direct-from-the-ore steel schemes.

The whole question of a direct process revolves around two factors: the expense of the apparatus and its dependability, and the successful conversion of the reduced iron, or "iron sponge" so-called, into a refined product which can compete in quality as well as in price with the present processes. The great difficulty has been not only the expense of the apparatus for reducing the ore and its cost of upkeep, but the handling of the iron sponge. This material, when in the highly heated condition, resulting from the reducting operation, has an intense affinity for oxygen and tends to at once re-oxidize and become iron oxide or ore again. Unless this iron sponge is handled very quickly, no process can be a complete success. It is therefore necessary to await practical demonstrations of the Basset or any process on this particular point.

So marvelous have been scientific and metallurgical developments in the past seven or eight years, it is unwise to look with disfavor on any direct steel-making process. Less than ten years ago it was said that steel would not be made in electric furnaces in the United States on any large scale, and yet to-day this country leads the world in this industry. It is possible that a direct steel-making process may still be a commercial success, but it is surely a considerable distance in the future, for to supplant the present extensive blast furnace industry of the United States is a herculean task. There is also to be remembered that modern steel-making practice on a large scale involves the conversion direct into steel of molten pig iron from the blast furnace by the use of mixers, converters and open-hearth or electric furnaces. This results in quick production of large quantities of high grade steel. There is, therefore, considerable skepticism as to whether any direct process can produce quality steel in quantity.

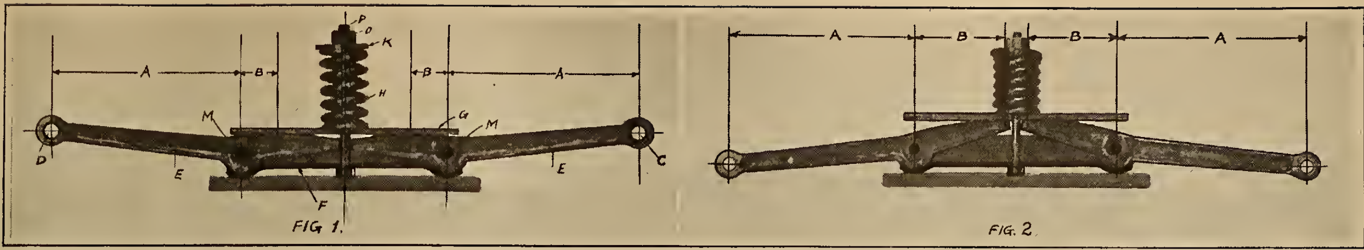
THE QUICKNESS OF RESPONSE OF CURRENT TO VOLTAGE IN A THERMIONIC TUBE

Steady voltages were applied between the hot and cold electrodes of a thermionic tube, for intervals of time which could be varied from 0.00001 second to a minute or longer. The mean current during the interval was measured by the Wheatstone bridge, using a null ballistic type.

Two types of thermionic tube were employed, one at a comparatively high gas pressure, the other at a far higher degree of exhaustion. It is found that on applying the voltage the initial rise of current to its maximum is followed by a fall, the rate of which diminishes with time. In the tube at the high gas pressure the effect is considerable, and the final value of the current may be less than half the initial value. In the case of the tubes at lower gas pressure the fall, though sensible, is far less pronounced, say, three or four per cent.

An experiment is described showing that whatever the change of conditions causing the observed fall may prove to be, this fall is not attributable merely to the high temperature of the filament, but is conditional on the thermionic current being permitted to flow.

The results point to the practical conclusion that in order to avoid phase difference between current and applied voltage at telephonic frequencies, of signals and consequent distortion at telephonic frequencies, of signals transmitted through a thermionic tube, the vacuum should be as high as possible.—D. Owen and R. M. Archer. *Proceedings of the Physical Society* of London, February 15, 1921.



FIGS. 1 AND 2. SUSPENSION DEVICE IN LIGHTLY LOADED (*LEFT*) AND HEAVILY LOADED (*RIGHT*) POSITIONS, ILLUSTRATING THE DIFFERENTIAL LEVER PRINCIPLE

Suspension Shock Absorber for Automobiles

New Construction Employing the Differential Lever Principle to Meet Variable Conditions

IN automobile construction one of the problems which calls for a solution as insistently as ever is the question of suspension. With higher rates of speeds, more variations in loading and the increasing use made of the springs to transmit the driving thrust as well as to take care of brake and torque reactions a demand has been created for better suspension, one which will satisfy present-day conditions.

A more intelligent study of the metallurgy of spring steel and the progress made in the heat treatment of springs in the past few years are factors which have brought the manufacture of springs to a very high state of perfection and yet in spite of the advances recorded in this direction one of the largest items of the upkeep during the life of the automobile is chargeable to the springs. This condition is largely due to the fact that the springs in use today are a compromise between two evils. If the strength of the spring be correctly proportioned to carry the empty or only partially loaded car it will be much too weak to sustain the full load. If on the other hand the strength of the spring be adequate to take care of the heaviest load it may be called upon to sustain it will be too unyielding for a lightly loaded car. To a certain extent this difficulty has been met by using a combination of springs of different strengths so arranged that the various units will come into action progressively, thus giving a graduated spring resistance. Of late the tendency has been for longer and more flexible springs giving a greater deflection, but owing to this greater movement of the vehicle body the liability to roll is largely increased.

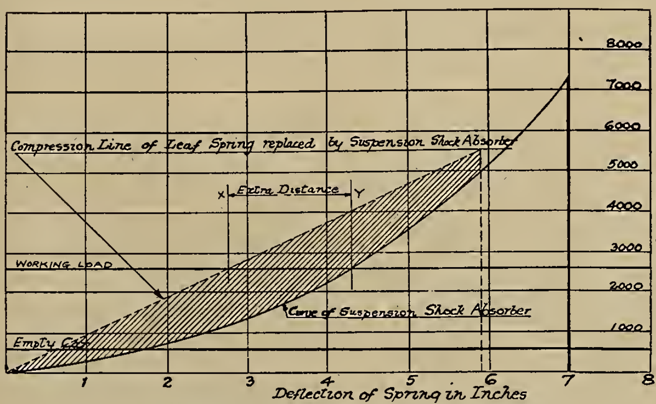
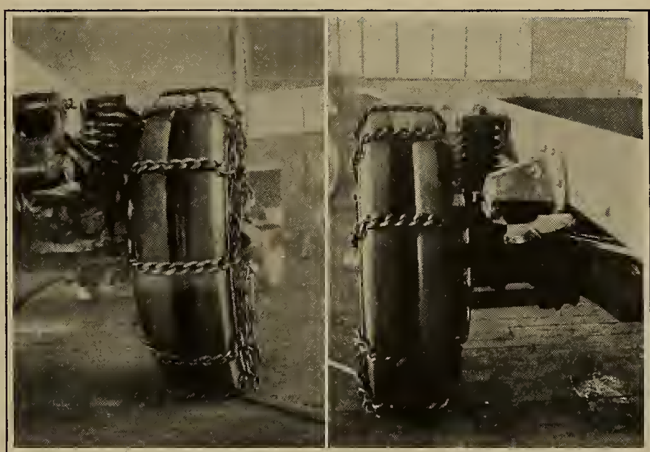


FIG. 3. GRAPHICAL COMPARISON BETWEEN THE IMPROVED SUSPENSION AND THE LEAF SPRING IT REPLACES



FIGS. 4 AND 5. SPRINGS USED FOR VEHICLES OF HEAVY LOAD CAPACITY

The great variety of shock absorbers, snubbers, bumpers auxiliary coil springs and spring oiling devices which are now on the market and find such a ready sale are in themselves an eloquent testimonial to the shortcomings of the leaf springs. The production of a suspension device which, contained in a single unit, would perform all the functions of these numerous accessories, be automatically adjustable to variations of loading and still be free from complications and readily repaired was the ideal kept in mind in the development of the suspension shock absorber described in this article.

A feature of interest in the design of the device is found in the application of the differential lever principle to secure the variable feature. The use of coil springs to supply the cushioning power also adds an added interest as their use in automobile construction without some extra device to dampen oscillations has not heretofore been found suitable. The leaf spring having friction between the leaves acts as a shock absorber and it is this quality together with its adaptability to fit in a restricted space which has made its use almost universal in road vehicle construction and preferred over the coil spring. The shock absorbing action found in the leaf spring is secured in the new device by the rolling and sliding action of a curve on a plane surface which makes the period of vibration dependent on the extent of the rolling and sliding between the coacting surfaces, thereby giving a fast period for small deflections and a slower period for greater deflections.

Reference to Fig. 1 shows the arrangement of the device in the lightly loaded position consisting of a casing "F" and two levers "E" pivoted to the casing through the pivotal points "M." The extreme ends of the lever at "C" and "D" are connected to the chassis in the usual manner while the underside of the casing resting on the axle at its central portion marked "J" is secured thereto in the usual manner. The inner end of the levers are in contact with the plate "G" which is held firmly in place by the compression in the coil spring "H." This plate is flanged at the sides for the purpose of adding stiffness and keeping a snug fit over the levers but for purposes of clearness these

have been omitted from the illustrations. Connection between the casing and the spring cap "K" is maintained by the bolt "P" which, bearing against the under face of the casing, passes between the levers and through the center of the coil spring and is threaded at the end to receive the nut "O." The weight of the car body causes the ends of the levers "C" and "D" to move downwardly, raising the inner end of the levers, displacing the plate "G" and compressing the coil spring. This action is transmitted through the long lever arm "A," while the force of the spring available to resist this movement acts through the comparatively short lever arm "B," giving a very yielding connection between the car body and axle. As the device is further compressed, however, the point of contact between lever and plate moves away from the fulcrum and increases the length of the lever arm "B," while arm "A" remains practically constant. The maximum travel is reached when the position of the lever as shown in Fig. 2 is assumed.

Fig. 3 is a graphical comparison between this improved suspension and the leaf spring which it replaces. The former is indicated on the diagram by the heavy curved line and the latter by the dotted line. Attention has already been directed to the advantage of flexibility under light loads and the extent to which this is carried out may be observed by the small angle which the curve makes with the horizontal line during the initial stages of the spring's deflection. This small inclination has the effect of lengthening the effective cushioning distance from free height to working normal load by the distance "XY," which eases the rebound movement very greatly. Another factor which eases the rebound movement is found in the reduction of the energy stored up in the spring when it is compressed by the amount indicated in the shaded area.

Figs. 1 and 2 show a design as used for ¾- and 1-ton trucks to replace a standard semi-elliptic. For heavier capacities two and three springs are used. Figs. 4 and 5 illustrate the application of the device to a 3-ton truck. Fig. 4 being a view looking from the rear of the truck and Fig. 5 a view looking at the front of the rear spring.

While the design shown in Figs. 1 and 2 is interchangeable with a semi-elliptic spring it was originally developed for use as a transverse suspension and as such has proved very successful counteracting the rolling tendency to a remarkable degree, reducing unsprung weight and permitting any desired deflection. When used in this connection the casing becomes the rear transverse member of the framing.

A summary of the advantages claimed for the new device and the points which have been kept in mind in the course of the development of the design are as follows:

The spring is flexible under light loads and relatively stiffer under heavy loads and live loads. The rebound is checked by reducing stored-up energy in spring to the minimum. It counteracts the tendency to roll. It transmits torque and thrust through the levers of the shock absorber. The moving parts are enclosed and lubricated. It serves as an effective shock absorber. All objectionable periodicity in the oscillation of the springs is damped out. All parts of the mechanism are accessible and easily removed and replaced. The unsprung weight is reduced by making the casing a portion of the frame. The parts entering into the manufacture of the shock absorber are standardized. The springs are adjustable to secure a given load at a certain deflection by turning one or two nuts.

Picric Acid as a Blasting Agent*

Finding Industrial Uses for Stores of Military Picric Acid Accumulated for War Purposes

By C. E. Munroe, Spencer P. Howell

Chief Explosives Chemist and Explosives Engineer, respectively, of the Bureau of Mines

As in the case of TNT previously presented[1], this report presents the results of an investigation to discover the safest and best way of utilizing picric acid for industrial blasting purposes.

The investigation was undertaken solely to aid in the salvage of the surplus picric acid accumulated for war uses and released by the declaration of the armistice. No funds were available nor have any been appropriated with which to defray the expense of converting this picric acid into any other form or to prepare any explosive mixture from it. The sole problem was to find appropriate uses for this military picric acid in existing needs and to show that it can be efficiently used in carrying out essential civil projects.

It is not intended by this publication to promote the use of picric acid as an industrial explosive further than is necessary for the proper utilization of this surplus. On the contrary, the authors believe that picric acid by itself is unlikely to come into general use as an industrial explosive, chiefly because of its cost but also, as shown by the clouds of smoke it emits on explosion and the nature of the reactions it undergoes, because we do not obtain from it its highest efficiency. As demonstrated in its previous use in Joveite, better results and higher efficiencies may be obtained by mixing picric acid in proper proportions with sodium nitrate or ammonium nitrate more completely to oxidize the picric acid, and another nitrosubstitution compound, such as nitronaphthalenes, with which to desensitize and waterproof the composition formed. By such admixture not only may the energy resident in the picric acid be more fully utilized but the cost of the resulting blasting explosive should be considerably less than that of picric acid.

Some quite serious accidents have occurred during the manufacture of picric acid and some in transportation, but in the accidents in transportation, other explosives being also involved, it has been difficult to determine the degree of responsibility of picric acid for such accidents. As later shown, picric acid is very stable and, when compared with other explosives, is not very sensitive to friction, to impact, to shock, or to ignition. In fact, as compared with the majority of explosives in common use, it may be regarded as a quite safe explosive. Marshall,[2] a well-recognized authority, says it "is nearly as insensitive as black powder," which refers to its insensitiveness to impact or friction but not to sparks or flame.

The gravest menace in its use arises from its tendency, when moist, to form picrates, for many of these are quite sensitive to friction, impact, and heat. They ignite and detonate picric acid with which they are in contact. Safety lies in keeping the picric acid away from picrates, and in so protecting it from contact with moisture and metals or metallic compounds that picrates cannot be formed from it.

But even when in the safest condition dry picric acid is an explosive, and like all other substances possessing explosive properties it should be handled, transported, stored and used with special care and surrounded by safeguards.

Since absolutely dry substances do not exist except under special rare conditions, the term *dry picric acid* as used in this publication means picric acid containing not more than two-tenths of one per cent of moisture.[3]

GENERAL CHARACTERISTICS

Picric acid appears as a highly crystalline powder having a lemon yellow color. This is the color required in the speci-

*Abstracted from a report (Serial No. 2243) of the U. S. Bureau of Mines.

[1]TNT as a Blasting Explosive, by Charles E. Munroe and Spencer P. Howell, Department Circular 94, United States Department of Agriculture.

[2]Marshall, Arthur, "Explosives," Vol. 1, 1917, p. 50.

[3]This definition is subject to revision as further information is obtained from demonstrations in the field.

fications of the U. S. War Department, but as manufactured, owing probably to the components in the water at the factory, it may be orange colored. Pure picric acid melts at 122.5° cent. (252.5.° fahr.). The War Department specifications require that is solidifying point shall not be lower than 120° cent. (248° fahr.). Since picric acid is found not to ignite until after it has become melted, its ignition point must be above 122.5° cent. The War Department specifications further require that the picric acid supplied to the department shall be of such degree of fineness that it shall pass through a 12-mesh screen having openings of 0.058 inch and wire of 0.025 inch diameter. The powder is free running and dusty, hence much care must be taken in drying, packing and handling it to avoid the forming of dust clouds and to prevent accumulations of picric acid dust about the working place. It stains the skin a clear yellow color where it comes in contact with the skin. This stain is very firmly fixed, but disappears after a time; and is not visible by gas light. Picric acid has an intensely bitter taste.

SOLUBILITY OF PICRIC ACID

According to Findlay, water at 15° cent. (59° fahr.) dissolves 1.16 per cent of picric acid and at 100° cent. (212° fahr.) 6.33 per cent. As compared with sugar, common salt, and many other well-known substances, picric acid is not a very soluble substance, yet it is decidedly more soluble in water than TNT is. It is, therefore, more hygroscopic than TNT, more prone to take up moisture from the atmosphere, and thus requires a larger measure of protection from the atmosphere than TNT does.

Picric acid has a high tinctorial power, for a very small weight of it will color a large weight of water or other substances. It is reported that one part of it will color 100,000 parts of water in which it is dissolved a distinctly visible yellow color. Many of the picrates are also quite soluble and also give a marked yellow to orange color to the solution. Naturally, when an explosive possesses such high coloring power as picric acid and picrates do, the ground and objects close to and round about the place where a charge is fired are likely to be stained by it, especially if the ground and objects are moist. Where explosives containing picric acid, such as Joveite, or picrates, have been fired in blasting such staining has been observed, and the users have concluded from this that a large part of the explosive failed to explode and that there had been a great waste of explosive. Bearing in mind that, as stated above, picric acid and picrates have a high tinctorial power it is conclusive that a very small quantity of the explosive would stain quite an extended surface. As a fact most of the staining produced in the use of such explosives in blasting was due to carelessness in handling the explosive by which some was spilled about the firing ground. When picric acid is supplied in properly made cartridges and these are properly handled neither the person using them nor the objects about the firing ground should be materially stained.

PACKAGES

Military picric acid, as offered for use in industrial operations, is packed in granular crystalline form, wet with ten to twenty per cent of water, either in boxes or in barrels. The boxes are of lock-cornered construction lined with two thicknesses of waxed or paraffined paper. In opening the boxes, if force is necessary, the covers should be pried off with wooden wedges.

Wet picric acid has also been received at the explosive experiment station in well-constructed tight barrels, unlined, containing 460 pounds of wet picric acid, and having a gross weight of 527 pounds. This type of container is permissible only if the picric acid is wet and shipped as an inflammable solid.

It is to be noted that, while wet picric acid may be shipped as an inflammable solid, redipped paraffined paper cartridges of dry picric acid must be shipped as a high explosive, and that the boxes must comply with I.C.C. 14.

The use of dry picric acid for industrial purposes should be restricted in all cases to its use in redipped paraffined paper cartridges, and it should never be used loose in bulk, for the reasons given above.

When dry picric acid is packed in cartridges, the apparent specific gravity of the charges may vary from 0.85 to 0.95, though the latter density is only obtained when the dry picric is tamped very hard by hand. On the other hand, 40 per cent straight nitroglycerin dynamite when so packed has an apparent specific gravity ranging from 1.15 to 1.34. Evidently for equal weights, dry picric acid cartridges will be more bulky than dynamite cartridges. As a consequence, greater diameter or greater length of charge must be used for dry picric acid charges than for dynamite charges of equal weight. This presents an advantage for the dynamite over dry picric acid.

PICRIC ACID AS A POISON

Unlike TNT, picric acid is but remotely poisonous. Referring to its use in beer as a substitute for hops Allen[4] states that rabbits and dogs have been killed by doses of it varying from 0.06 to 0.6 grams (0.9 to 9 grains). Ehrenfried[5] states that there is no fatal case of picric acid poisoning on record, but 15 to 30 grains are sufficient to cause toxic symptoms. Koelsch,[6] writing of experiences during the Great War, says that in loading plants where picric acid was pressed in forms to be loaded into fuses or into shell, or melted and cast into shell, the operators were exposed to picric acid dust and fumes but that the physiological effects produced on them was in most cases negligible. Neither acute nor chronic poisoning was observed. Some supersensitive workers experienced irritation in throat, nose and eyes, loss of appetite, and pains in legs and head, but no special precautions were deemed necessary except the transfer of these sensitive workers to other employment. In a wide experience with picric acid by the authors (extending for one of us over a term of 45 years), covering the manufacture of picric acid, many picrates, and picric powders, the use of picric acid in shell loading, the use of picric acid alone and of picric powders in blasting in the open, in quarries and in mines, and the analyzing and testing of picric acid, picrates and picric powders where many men have been employed in these operations, we have never encountered an instance of poisoning from it. We feel justified in expressing the belief that this menace is very remote.

IGNITION OF PICRIC ACID

Picric acid is ignited by flame or sufficient exposure to heat. It is very insensitive to ignition by friction or sparks. When heated in mass it melts before it ignites and therefore if a hot body, such as a heated steel ball, is brought in contact with a mass of picric acid, unless the mass of the ball is quite large or the ball is very highly heated, the heat of the ball may be, and, in instances, has been, expended in melting the picric acid without igniting it. Burning picric acid either unconfined or when confined in packing cases, or boxes, has been extinguished by drenching it with water, especially from automatic extinguishers. Hence, factories, drying houses, packing houses and magazines containing picric acid will receive a large measure of protection from the installation of automatic fire extinguishers in them. Picric acid in burning emits fumes which produce a peculiar bitter sensation in the back of the throat. This is a most delicate and characteristic test. The smoke is black but not so dense as that from burning TNT. As regards fire the most danger is to be apprehended from picric acid dust, for, in common with all combustible dusts, picric acid dust forms explosive mixtures with air, and as picric acid is more readily ignited than coal, corn, wheat, starch and many other inflammable and combustible dusts whose mixtures with air have repeatedly, on ignition,

[4] Allan, A. H., "Commercial Organic Analysis," 1900, Vol. 3, pt. 1, p. 119.

[5] U. S. Dispensatory, 20th ed., p. 1165.

[6] Koelsch, F., "Toxicity of Picric Acid," Z. gas. Schiess Sprengstoffw., 1920, Vol. 15, pp. 104-107.

SOLID WHITE OAK STUMP 3 FEET 6 INCHES IN DIAMETER WHICH WAS BLASTED IN TEST NO. 2

given rise to explosions, the picric acid dust is more dangerous than coal and cereal dusts. Hence in factories and packing houses extreme care should be taken to prevent dust from arising, and also to prevent its accumulating on the tables, walls, rafters, ledges or any part of the building, and especially on any part of the heater system. In these buildings good housekeeping is especially essential.

Many of the more commonly known picrates, especially iron picrate, are quite easily ignited by friction, percussion and heat. Iron picrate has often been formed on iron water pipes and steam pipes, tools and vessels in works where picric acid was made or used. There are many records of "a flash" having followed when a mechanic, to make necessary repairs or changes, started to work, in the ordinary manner, on these pipes or vessels.

EXPLOSION OF PICRIC ACID

Although, following Turpin's development of melinite, picric acid has been melted in many thousand instances and cast into shell, and, although picric acid has repeatedly been melted, by direct contact of the crucible containing it with an open fire, without causing the picric acid to explode, yet, in Berthelot's well-known method of demonstrating the explosibility of chemical substances, picric acid does explode when a small portion of it is dropped into a glass test tube which has previously been heated to a high temperature.

Explosions have occurred in picric acid factories following the breaking out of fires in such factories, though in some instances quantities of picric acid exceeding 2,000 pounds, and, in one instance as much as 5,500 pounds, burned away without an explosion taking place. It has been demonstrated that where basic metallic oxides, such as the lead oxide, known as litharge, are present with picric acid violent explosions were readily produced by heating them.

Picric acid, when loosely packed, may be detonated by a No. 6 detonator provided the detonator is so inserted in the mass that it is in close contact with the picric acid and that the latter is perfectly dry. It is, however, bad practice in blasting to use that weakest strength detonator which has been found to detonate an explosive. Under the most careful management a "failure to fire" may occur which might not occur if a "stronger" detonator were used. "Failure to fire" usually creates a dangerous situation. The difference in cost between a No. 6 and a No. 8 detonator is less than two cents. While picric acid is more sensitive to detonation than TNT is, it is advised that No. 8 detonators be used for detonating picric acid, since for an expenditure of less than two cents a large measure of certainty in firing is assured and "misfires," which often are quite costly, become practically unlikely.[7]

GASEOUS PRODUCTS OF DETONATION

An explosion is produced by means of picric acid when fired by itself owing to the fact that the mass of picric acid in the solid state, is rapidly decomposed and converted into a mixture of highly heated gases. The temperature realized, according to Brunswig (Brunswig, H. "Explosives." Translated by Charles E. Munroe and Alton L. Kibler. New York, 1912, p. 152), is 2430° cent. (4406° fahr.), though this, while always high, must vary somewhat with the conditions under which the explosion takes place. The explosion may, according to circumstances, take the form of a simple explosion such as always characterizes the explosion of black gunpowder or of a detonation such as always characterizes the explosion of mercury fulminate. The difference between the two forms of explosion lies chiefly in the speed which according to Brunswig (Brunswig, H. Work cited, p. 98) was found to be at the rate of 300 meters (984.25 feet), per second for gunpowder and 3,920 meters (12,861 feet) per second for fulminate of mercury.

Picric acid may explode (1) by simple explosion and be converted into carbon dioxide, carbon monoxide, hydrogen and nitrogen which appears as gases, and free carbon, which appears as soot and imparts a dark to gray color to the "smoke"; or it may explode (2) by detonation giving carbon monoxide water, hydrogen and nitrogen, all in the gaseous state; or its explosion may take the form of a partial detonation or a detonation of a low order (3) yielding some carbon dioxide as in (1) and less water than in (2).

Carbon monoxide, hydrogen and methane are all easily ignited and combustible gases and can form explosive mixtures with air. Carbon monoxide is an extremely poisonous substance, and it is given off in large quantities by picric acid whatever kind of explosion it undergoes. Hence picric acid, by itself, should never be used as an explosive in underground mines, or in close places where the gaseous products are confined and held, for they might give rise to accidents from gas explosions and especially from poisoning. Where ventilation is complete, as in the open air, and especially when operators and observers stand to the windward of a shot there is

[7]This statement is amplified in "Dangers in Using Low-grade Foreign Detonators," by Charles E. Munroe, Reports of Investigations, Bureau of Mines, Serial N. 2226, March, 1921.

little likelihood that anyone will be affected by the gaseous products or fumes.

Picric acid has been shown by tests to be relatively insensitive to explosion by friction or by percussion, and certainly to be less sensitive to these influences than industrial explosives which have been in quite general use.

RELATIVE EFFICIENCY

In determining the relative efficiencies of explosives in use, the Bureau of Mines has long employed the "unit deflective charge," and the "rate of detonation" as criteria. The unit deflective charge is ascertained by exploding a known weight of the explosive in the ballistic pendulum and this term, "unit deflective charge," is defined as "that weight of an explosive which will swing the ballistic pendulum the same distance as one-half pound of 40 per cent straight nitroglycerine dynamite." It appears that explosives of which the unit deflective charge is smaller have the greater propulsive capacity; hence, the unit deflective charge is considered a measure of the ability of an explosive to dislodge and bring down material in which it is exploded. Picric acid is stronger by 18 per cent when so measured than 40 per cent straight nitroglycerin dynamite.

TRAUZL LEAD-BLOCK TEST

The "trauzl lead-block test" measures the comparative disruptive effect of different explosives fired in charges of equal weights, under moderate confinement, in small cylindrical bore holes of equal volumes and dimensions, formed in carefully prepared large lead blocks, and measuring the resulting increase in volume of the cavity in the lead block.

The results of tests of dry picric acid and other explosives when fired in cavities in lead blocks by the Trauzl method as practiced by the Bureau of Mines, are given in the following tabulation, in terms of the increase in volume of the cavities in each case and these results are compared with one another by taking 40 per cent "straight" nitroglycerin dynamite as a standard with a value of 100 per cent:

Table 1.—Trauzl Lead Block Expansion of Nine Explosives

Explosive	Expansion in c.c.	Per cent
Blasting gelatin	400	149.8
60% "straight" dynamite	321	120.2
Picric acid	316	118.4
Granulated TNT	302	113.1
50% "straight" dynamite	281	105.2
40% "straight" dynamite	267	100.0
40% ammonia dynamite	202	75.7
40% gelatin dynamite	195	73.0
Black blasting powder	28	10.5

CHARGING BORE HOLES

Picric acid should be charged into bore holes, primed, tamped, and stemmed in the approved manner customarily followed in the use of cartridges of high explosives in blasting, special care being taken in charging wet holes not to tear or break the cartridge case or wrapper while loading the cartridge into the hole or while tamping it, for water rapidly reduces the sensitiveness of picric acid to detonation.

To secure the most efficient results a sufficient quantity of stemming should be used and this should be well tamped. There is no doubt that much explosive is wasted in blasting owing to the failure to observe these instructions. The great economy effected in the use of explosives in mines by following these instructions has been thoroughly shown by Snelling and Hall (Snelling, W. O., and Hall, Clarence, "The Effect of Stemming on the Efficiency of Explosives," Bureau of Mines, Technical Paper 17).

Picric acid may be used in chambering holes, for subsequent charging with black blasting powder, just as dynamite is used. It may also be used in "adobeying" or "mud-capping" bowlders by placing the charge on the bowlder and covering it with moist clay, earth or sand by which to confine the charge.

When picric acid shots are fired, if the detonation is complete, there will be produced a dark bluish-gray smoke, the unstemmed shots usually giving a darker smoke than the stemmed shots. In incomplete detonation the smoke has a greenish-yellow color and a deposit of undecomposed explosive may be formed on surrounding objects.

Instances arise where in an emergency it is desired to remove obstructions in blast furnaces, such as salamanders, or to break up slag piles while the material is still hot. On account of its high initial explosion temperature and great explosive energy picric acid appears, among explosives, to be the one best adapted to such use, especially when of high density, for experiment has shown that the rate of detonation of picric acid increases with the density, and at very high densities approaches the unusually high rate of 8,000 meters per second. It is recommended that when so used the temperature of the bore hole should not exceed 76.7° cent. (170° fahr.) and that the shot should be surrounded with special safeguards, and the charge be fired promptly.

PRACTICAL DEMONSTRATIONS IN THE FIELD

The practical value of picric acid for general blasting purposes, other than in underground mining, has been demonstrated by field tests in stump blasting and bowlder breaking

THE BLAST IN TEST NO. 2

made on the grounds of the Bureau of Mines explosives experiment station at Bruceton, Pennsylvania, by J. E. Tiffany, assistant explosives engineer.

For the purpose of these tests a quantity of picric acid was dried and found to contain 0.38 per cent of moisture. It was loaded in 1¼- by 8-inch paraffined paper shells with great ease. Each cartridge weighed about 170 grams (6 ounces).

The stumps were all rooted in clay and the surface of the ground was on a slope dipping to the north in the case of the first two stumps and almost level for the third stump. The holes were about 1½ inch in diameter at the bottom and were in some cases over 2 inches at the top. They were in every case put down in the ground under the stump or lateral roots by means of a pointed steel bar. The cartridges were loaded in the holes and the primer placed on top with a No. 6 electric detonator centrally inserted in the primer. A wad of stiff paper was placed on top of each charge used in stump blasting and the hole was then tamped with clay stemming to the top of the hole. The blasts were fired by means of a push-down multiple hole blasting machine, connected to duplex

lead wires and in the case of the stump blasts the electric detonators were connected for each stump in series, the two free legs being connected to the duplex leading wires, while in the adobe shot the legs of the one electric detonator used was connected to the duplex leading wires.

Test 1.—A solid white oak stump, which was two feet in diameter and standing about 2½ feet out of the ground was removed by firing picric acid under it. Two holes were bored, each 3½ feet long, of which one was in the ground on the higher side, and the other on the lower side. Both holes were so inclined that the bottom of each hole was about under the center of the stump. The upper hole was loaded with two cartridges of picric acid and one-half cartridge primed with a No. 6 electric detonator placed last in the hole. The lower hole was charged in a similar manner using one cartridge less. The six cartridges thus used weighed about 2¼ pounds. As a result of the explosion there was a muffled report, accompanied by a cloud of smoke of a light gray color. The stump was split into several small pieces and a small crater was left in the ground.

Test 2.—A solid white oak stump 3 feet 6 inches in diameter was blasted. There were 3 well defined lateral roots to this stump each of them having smaller branch roots. On the upper side the stump stood about 2 feet above the ground. Four 4-ft. holes were located and put down in the ground in such a direction that when loaded there were 5 pounds of picric acid cartridges directly under the main part of the stump, while 6 holes were placed under the lateral roots in which a total of 4½ pounds of picric acid cartridges were loaded. Some of these holes were loaded with one cartridge while others had as much as two cartridges. The holes were all very wet in the bottom so that a 1¼- by 8-inch paraffined paper shell was cut across into halves, each one of which was almost filled with sawdust and its upper end closed with a small wad of newspaper. The latter end was inserted in the hole first. Each hole had such a sawdust cartridge placed in it, the purpose in mind being that the water in the hole would be absorbed by the sawdust after soaking through the newspaper, and thus prevent the moistening of the explosive. The report of the explosion was somewhat muffled, the smoke was of a light gray color.

As a result of the blast the main part of the stump was split into about three main fragments of equal size which were thrown in the air, one piece of which landed about 45 feet away while the other two pieces were found close to each other about twenty feet away but in another direction.

The crater remaining after the blast was about 10 feet in diameter and about 4 feet deep.

Test 3.—A solid walnut stump, 2 feet in diameter, was blasted. Three holes were bored in the ground inclined toward each other so that the bottoms of the holes were under the stump. The holes were about 3 feet deep and were loaded with a total of 3 pounds of picric acid made up in paraffined paper shell. Two of the holes were each loaded with two cartridges with primer on top consisting of a half cartridge in which a No. 6 electric detonator was centrally inserted while the third hole was loaded with 3 of the cartridges and a primer similar to that used in other holes.

The blast split the stump in three main pieces, two of which were afterward found 20 to 45 feet, respectively, from the original position of the stump. One piece fell back in the crater left by the removal of the stump.

Test 4.—A sandstone bowlder 13 inches by 23 inches by 66 inches was selected for the purpose of demonstrating the suitability of picric acid for breaking bowlders. The bowlder was resting on solid rock. Four picric acid cartridges were laid on the center rock, in pairs, the ends of one pair touching the ends of the other pair. One of the four cartridges had inserted in it a No. 6 electric detonator. The cartridges were then covered with clay to a thickness of about 3 inches and fired. The bowlder was shattered throughout its entire mass as a result of the explosion of one and one-half pounds of picric acid. Fifty per cent of the bowlder was broken into fragments of about two-inch size.

CONCLUSIONS

The results of the above described blasts in removing stumps and in breaking a bowlder by means of an adobe shot using picric acid having a moisture content of 0.38 per cent and loaded in 1¼- by 8-inch paraffined paper shells show that picric acid is suitable for use in work similar to that described in this report. Especial attention is directed to the successful firing of picric acid in very wet boreholes in Test No. 2, and that special precautions were used to protect the explosive from water in the bore hole.

Arrangements have been made for a coöperative investigation of the use of picric acid as a blasting agent by the College of Agriculture of the University of Wisconsin, analogous to that made on TNT, and described in Department Circular No. 94 of the Department of Agriculture.

MANUFACTURE OF RESEARCH CHEMICALS

The University of Wisconsin announces an experiment for this summer during which eight advanced students will be given a course during which they will be paid for their work while producing research chemicals needed in the various scientific departments of the university. The most promising students will be selected for this work with a view to giving them intensive training in organic chemical preparations on a large scale. The various departments of the university have been asked to make known their needs so that a program of work may be outlined.

CRATER ABOUT 10 FEET IN DIAMETER AND 4 FEET DEEP RESULTING FROM TEST NO. 2

Sounds of Meteorological Origin*

Thundering, Roaring, Howling, Shrieking, Humming, Murmuring and Whispering of Nature

By W. J. Humphreys, C.E., Ph.D.
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PROBABLY all, or nearly all, who have experienced a cold winter are familiar with the cheery cry of the snow as it is pressed against a hard surface by the steel tire of a wagon, for instance, or even upon a pavement by the heels of one's boots.

When the temperature is just a little below the freezing point, the snow, then in fine condition for snowballing, does not creak, and the track of the wheel is marked by a strip of more or less compact ice. On the other hand, when it is so cold that the snow will not ball, its voice is loud, and the track left by the wheel is now marked, not by a strip of compact ice, but by a trail of crushed and powdered crystals.

In the first case, that is, when the temperature is only a little below freezing, the snow crystals obviously melt, to a greater or less extent, as a result of the pressure to which they are subjected, and undergo regelation as soon as the pressure is removed. The yielding is gentle and progressive through melting and flowing, and not of that abrupt nature essential to the production of sound.

In the second case, however, or when the snow is too cold to melt under the pressure applied, its yieldings and readjustments are abrupt and jerky incident to the crushing of the crystals and their slippage in a dry condition over each other. It is these abrupt yieldings, these sudden breaks and slips of its dry crystals, that produce the familiar cold-weather creak and cry of the snow.

THUNDER

Cause.—Thunder, one of the most familiar and certainly the most impressive of all meteorological sounds, has been "explained" in many ridiculous ways, but generally, perhaps, just accepted. Any careful observation, however, will soon show that thunder is associated with lightning, and that the lightning flash always precedes the thunder. Clearly, then, thunder is somehow caused by lightning.

Now, it is known that sudden and intense heating, and molecular dissociation occur along the path of a lightning discharge. Hence a corresponding abrupt expansion, simulating a violent explosion, also occurs along this path; and this expansion in turn produces a compression wave in the surrounding atmosphere that travels outward exactly as would any other sound wave.

Musical Thunder.—It occasionally happens, when one is near the path of a lightning flash, that the thunder heard begins with a musical note. This is due to the fact that some lightning discharges—the flickering type—consist of a series of rapid flashes that occasionally are nearly enough regular, and of such frequency, as to produce a quasi-musical note.

Duration.—The long continuation of thunder is due, chiefly, to the great difference in the distances of the nearest and farthest points of the lightning path from the observer. If this difference is five miles, as it occasionally is, the duration of the thunder, owing to this cause alone, is roughly 24 seconds.

The duration of thunder is also prolonged by reflection. Occasionally the echo prolongation is very pronounced, but it is everywhere variable and uncertain.

Rumbling.—The great variations in the intensity of thunder that constitute its characteristic rumbling are due:

(*a*) To crookedness of path. The thunder starts from all parts of the discharge path simultaneously, or practically so, and thus the observer hears simultaneously the thunder from the whole of any portion of the path that happens to be at a constant distance from him. Now, as the path usually is very crooked, it generally happens that many portions of it are at one or another nearly constant distance from any given point. Hence, almost every peal of thunder is of irregular intensity, and as no two lightning paths are alike so also each peal of thunder differs from every other.

(*b*) To the sequence of discharges. Obviously, when a number of discharges follow each other in rapid succession—when the lightning is flickering—there is likely to be more or less interference between the several sound pulses resulting now in partial neutralization and again in reinforcement, the whole merging into an irregular rumble.

(*c*) To reflection. Reflection by mountains, hills and other objects may occasionally be effective in prolonging the noise of thunder and accentuating its rumble. However, mountains and hills are not nearly so essential to the rumble of thunder as occasionally they are said to be, for the rumble of the thunder, whether in the valley ,on the plain or on the peak, is substantially the same.

Distance Heard.—Thunder seldom is heard more than 15 miles. This is much less than the distance to which cannon are sometimes heard. The circumstances in the two cases, however, are radically different. Thus, the sound energy from the cannon is relatively concentrated since it all starts from a single point and spreads out in a hemispherical shell, whereas, that of thunder starts, not from a single point, but from a crooked line often miles long. Furthermore, cannon often are fired when the surface air in which the firing occurs, is very still and otherwise in the best state for long transmissions of sound. Thunder, on the other hand, seldom occurs except when the winds are turbulent and the general conditions very adverse to sound propagation. Finally, the density of the air is greater at the cannon than along the lightning path, and hence its sound energy per unit volume, other things being equal, is also correspondingly greater in the former than in the latter case.

BRONTIDES

From time immemorial low, rumbling, thunder-like noises (brontides, *mistpoeffers*, "Barisal guns," etc), of short duration, and that certainly are not thunder, for they often occur when the sky is clear, have been heard in many parts of the world, both singly and in irregular series. They appear to come from a distance, but of uncertain direction, and are most frequent in actively seismic regions.

Apparently, then, the true brontides (many other sounds have often been mistakenly reported as brontides) are only the rumblings of earthquakes too feeble for registration or other than aural detection. And this inference is strengthened, if not indeed confirmed, by the fact that earthquake adjustments have been known to occur in a long irregular series of shocks that became feebler and feebler until only the characteristic low rumbles (then properly called brontides) remained, as presumable evidence of their passage.

HOWLING OF THE WIND

One of the compensations for being snowbound on a windy day is the pleasure of listening to the well-known howling of the wind as it sweeps by the chimneys and over the gables, and wondering where it gets its many voices, or, indeed, any voice at all. Nor is the wonderment yet over, for the problem of the howling of the wind has never been completely solved, at least not in the fullness of all the differential equations that tell the whole story. This much, however, is known: the howling, like the other æolian sounds discussed below, is due to eddy motions in the atmosphere immediately beyond the obstructing object. There is no resonance or other organ-

*Abstracted from the *Journal of the Franklin Institute* May, 1921, Vol. 191, No. 5.

pipe action, for the change from one pitch to another is not by jumps, as it is in all pipes, but gradual.

Let the direction of the wind make an appreciable angle with the roof and let the latter either project a little beyond the gable wall or, at least, come up flush with it. Under these conditions the wind will have its maximum velocity as it leaves the roof, and there in only a comparatively thin sheet. This sheet in turn, immediately on escaping the roof, drags along, through viscosity, some of the air just beneath it, and is itself slightly deflected in the direction of the consequent pull. In this way an abrupt change in the direction of flow is produced at the edge of the roof and hence an eddy will immediately start at that place. One effect of such an eddy, since it enters the current from relatively still air, is to decrease slightly the velocity of that current. It is quickly carried on, however, and the eddy-forming conditions are thereby renewed. In this general manner, presumably, eddy after eddy is formed at the edge of the roof with such frequency and such approach to regularity as to produce a more or less musical note.

These sounds generally are much better heard indoors than out. This is largely, if not wholly, because one is there far less disturbed by the innumerable other outdoor noises, especially the continuous and annoying whisper of the wind right in one's ears—also an eddy effect.

HUMMING OF WIRES

Few things, perhaps, have been more absurdly "explained" than has the well-known humming of telegraph and telephone wires, and that in spite of the fact that the correct explanation has long been at hand.

It was shown by Strouhal[1] that wind normal to a cylinder, such as a stretched wire, produces æolian tones even when the cylinder itself takes no part in the vibration; that the pitch of the note thus produced, independent alike of the material, length, and tension of the wire, varies directly as the speed, u, of the wind and inversely as the diameter, d, of the obstructing rod; and that the number, n, of such vibrations per second is given, approximately, by the equation

$$n = .185\ u/d$$

the units being the centimeter and second.

Whenever the tone thus produced coincides with one of the proper tones (fundamental or a harmonic) of the wire, the wire itself, if suitably supported, then vigorously vibrates, normal to the direction of the wind, and thereby increases the loudness and also holds the pitch fixed over a considerable range of wind velocity. The sound in question, however, that is, the humming of telegraph and telephone wires, is not due to the elasticity of the wires (the pitch changes gradually with wind velocity and not from harmonic to harmonic), but to the instability of the vortex sheets their obstruction introduces into the air as it rushes by them. This obvious and, indeed, unavoidable deduction from Strouhal's experiments, just referred to, is abundantly confirmed by cinema photographs of water eddies, due to flow past a cylinder, made at the National Physical Laboratory. Vortex whirls developed at regular intervals, alternately to the right and left of the interfering cylinder, while the eddy mass vibrated from side to side in the same period.

The complete mathematical analysis of these and similar vortices, giving the deduction of Strouhal's rules, and many others, would be both interesting and valuable, but it appears that this important problem has not yet been fully solved. Much progress, however, toward this solution, has been made by v. Kármán[2] and by v. Kármán and Rubach,[3] who have shown that evenly spaced vortices alternately on opposite sides is a stable arrangement, and the only one.

It is well known that the humming of telegraph and telephone wires is loudest when the wires are tightly stretched, as they generally are during cold weather. This appears to be because the eddies thus produced in the wind vary the tension on the wire, and rapidly the more so the tighter, or straighter, it becomes. Now these variations of tension are transmitted to the posts which in turn act as sounding boards, analogous to the sounding board of a piano, and hence largely increase the volume of the sound, whatever its pitch.

[1] *Ann. d. Phys.*, p. 216, 1878. See also Lord Rayleigh, *Phil. Mag.*, p. 433, 1915.

[2] *Göttingen Nachrichten*, 1912, *Heft*, p. 547.

[3] *Phys. Zeit.*, p. 49, 1912.

WHISPERING OF TREES

From the experiments of Strouhal, above referred to, it is evident that pine needles, bare twigs, and even the branches of trees, must all produce æolian notes—that trees must have voices, even voices that are characteristic of the species. And they do. The muffled plaint of the oak at the wintry blast, for instance, has but little in common with the sibilant sigh of the pine. And the reason is obvious; the twigs and branches of the one, because relatively large and of many sizes, produce a multitude of low tones, while the innumerable fine needles of the other give a smaller range of high-pitched notes.

It may be granted that, as shown by experiment, each twig and other similar obstacle in the wind must produce an æolian note. But how, one must ask, do a multitude of such notes blend together—how are the pitch and loudness of the resultant related to the like properties of the constituents?

[*The author here gives a mathematical demonstration which we omit, and arrives at the following conclusions.*—EDITOR.]

From the above two laws, namely (1) that the pitch of a composite note is the approximate average of those of its constituents, and (2) that the mean intensity is the sum of the individual intensities, it appears (*a*) that the pitch of the æolian whisper of a tree is essentially that of its average twig, or needle, if the tree be a pine, and (*b*) that though the note of the twig may be inaudible, even at close range, the tree may often be heard some distance away.

Just as the æolian whispers of the myriads of needles on a single pine tree, or of the numerous twigs on an oak, for example, blend into a whisper of the same average pitch but vastly greater volume, so too the whisperings of a great many individual trees merge into the well-known murmur of the forest.

ROARING OF THE MOUNTAIN

When a mountain well wooded along and near its top is crossed by a wind approximately at right angles to its axis, it often happens, particularly during winter when there are no protecting leaves on the trees (or at any time if the forest is pine), that, in the leeward valley, one hears a low sighing or moaning noise which, as the wind over the crest grows to a gale, gradually swells to a cataract roar. This, too, is only another instance of the combined effects of myriads upon myriads of æolian whispers, accentuated, indeed, along the valley through their crude focusing by the descending winds.

ODDS AND ENDS

In addition to the above, there also are numerous other sounds that might, more or less justly, be called meteorological, such as the *rustle of leaves*, due to the rubbing together of the foliage as trees and branches are shaken by the wind; the *roar and whir of the tornado*, due to the wrecking by the storm of all things in its path, to the wind eddies engendered by every obstruction, and to the more or less continuous rumble of thunder; the *patter of rain*, due to the successive falling of innumerable drops on to a roof, pavement, compact soil, and the like, or into a body of water; the *rattle of sleet* (frozen raindrops), due to the driving of the small ice pellets against any hard object—the windowpane, for instance; the *clatter of hail*, due to the fall of relatively large lumps of ice upon a roof, or other hard surface, and even (occasionally reported in connection with severe storms) to their striking together in mid-air; the *detonations of meteorites*, due to violent disruptions owing to their sudden and intense heating; the *sizzle of St. Elmo's fire*, the faint crackle of the constant stream of feeble electric discharges from mast tips or other points thus strangely illuminated; the *swish of the aurora*, due, apparently, to autosuggestion, and, of course, many more.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a coöperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

WHAT DO YOU KNOW ABOUT DIATOMS?*

By H. P. Little, Secretary,
Division of Geology and Geography, National Research Council

What is a diatom? The dictionaries and the botanists say that the Diatomaceæ are "a family of microscopic algæ inhabiting fresh and salt water. Each individual . . . consists of two more or less silicified halves, the older of which is slightly larger than the younger and fits over it like the lid of a box." Microscopic, algal, silica-covered, box-like, or even better, pill-box-like—there is the story, especially when it is added that the algæ are a very simple type of plant without roots, stalks, or seeds.

Why are diatoms interesting? Why did the National Research Council interest itself in advancing research on these minute plants and why were the Bureau of Fisheries, the Coast and Geodetic Survey, the Hydrographic Office, the Geological Survey and the National Museum so willing to give effective coöperation in this research?

The Bureau of Fisheries was interested because diatoms furnish food to fish, oysters and other fresh and salt water animals to the extent of countless millions of tons per year. Even to many of the whales they furnish an appreciable quota of their food consisting of material strained out of the sea-water by the so-called whalebone—"so-called" because it consists not of bone but of flat horny plates developed from the palate. The breeding grounds, feeding grounds, and migrations of many of our important food fishes are determined by, and vary with, the existence of adequate supplies of living diatoms of various kinds. Evidently the Bureau of Fisheries, concerned with discovering the best methods of utilizing the resources of the sea, could not fail to be interested in forwarding any kind of research which promised more intimate knowledge of forms so vitally connected with the great natural food resource. And now that the days of cheap meat are past, and fish furnish so important a quota of food, Mr. Everyman is evidently interested in diatoms, too.

The Coast and Geodetic Survey and the Hydrographic Office were concerned because navigation is helped by diatom investigations. Everyone knows that there are ocean currents of varying strength and direction and that they influence the course of ships. Navigation charts show these currents, so far as they are known, but such knowledge is by no means complete. The Prince of Monaco, who has recently been received with honors in the United States, has done much investigation of currents by releasing numerous floating bottles which contained the address to which the ultimate finder should return them. Recently, before the National Academy of Sciences in Washington, he told how successful he had been, from the knowledge thus obtained, in forecasting the course which mines released in the recent war would take, to the great benefit of shipping. Now some varieties of diatoms are restricted to specific areas as breeding grounds, and since their skeletons, because of their exceeding minuteness, sink with great slowness and are carried by currents thousands of miles from their original habitat, they serve as millions of floats to mark the course of currents, just as did the Prince's bottles. It seems very likely that a critical study of marine diatoms will reveal other species which are restricted and hence will give the hydrographer still more aid in his difficult task. A specific and interesting example of the possible use of diatoms as markers of ocean currents is found in the investigation of arctic waters which bring ice-bergs from the north into the path of ocean-going vessels and cause wrecks such as the "Titanic" disaster of 1912. Since these little plants prosper amazingly in the cold arctic waters, it is likely that they would be of assistance in tracing the origin and course of the iceberg-bearing currents. At any rate, such a possibility has commended itself to the Government Board which is studying the matter.

The Smithsonian Institution is interested in diatoms from their relation to the general progress of human knowledge and information. Their exact relations in the world of plants are not entirely clear and their classification within their family is incomplete. The fulfilment of the practical uses above referred to and others still to be given is evidently closely joined with the type of work with which the Smithsonian Institution is particularly concerned.

The Geological Survey and individual geologists have a direct interest in diatoms, and in several ways. For one thing diatoms in past geologic ages indicated, as now, climatic elements and other environmental conditions of by-gone ages, such as degree of alkalinity or acidity of waters then existing. There is also a distinctly practical side in the relation of diatoms and geology. Take the present oil boom. The California oil fields are exceeded in production, among those of the United States, only by those of the Mid-continental field; state for state, she outranks them all. Of California's production the Sunset-Midway oil field furnishes nearly half and includes the Lakeview Gusher which yielded 8,000,000 barrels of oil in eighteen months. According to a recent publication of the United States Geological Survey the petroleum in this field "has originated . . . chiefly from the alteration of organic matter contained in diatoms and formanifers. . . ." Different species of these diatoms lived at different times; oil may have formed in associated beds and by identifying the species of diatom the relative positions of the oil-bearing horizons can often be determined. Furthermore, the remains of the diatoms themselves are used in so many ways in common things that probably everyone in civilized countries buys diatoms as frequently as he buys clothes. For instance, their sharp-edged siliceous skeletons make an excellent mild abrasive which is extensively used in tooth pastes and in various kinds of scouring powders, especially for metal polishing. Various porcelains contain the remains of diatoms and special filters are made from them. According to *Mineral Resources*, published annually by the United States Geological Survey, the skeletons of diatoms find the following additional uses: as a holder of nitroglycerin in dynamite because of their porosity in the aggregate; as an insulating packing material for safes, steam boilers, and metallurgical apparatus, because of their porosity, lightness, and non-conductivity of heat; in making insulating brick and as a fire-proof building material; and in the making of records for talking machines. Germany, partic-

*Based, in large part, on the report of the National Research Council's Committee on Paleobotany, David White, Chairman.

ularly, has found various advantageous uses; the preparation of artificial fertilizers especially in the absorption of liquid manures; the manufacture of waterglass—the increasing number who "put down" their eggs to beat the high cost of living will appreciate this—of various cements, of glazing for tiles, and of artificial stone; as a carrier of ultramarine and various pigments, aniline and alizarin colors; in filling paper; and in the preparation of sealing wax, fireworks, gutta-percha objects, Swedish matches, solidified bromine, papier mâché, and many other articles. The Geological Survey is expected to keep manufacturers informed as to the location of adequate supplies of the right kind of diatom deposits for these and other industrial uses; they are of necessity interested in research which throws light on material offering possibility of such varied applications.

There is another use of diatom remains which is of particular interest, and that is in the refining and clarifying of sugar—and here again Mr. Everyman becomes mightily interested. Several years ago, the eastern refineries began to filter their juices through diatom remains, though the uninitiated would not have recognized them traveling under the name of *kieselguhr*. Recently* experiments have been carried on in Louisiana attempting to devise methods of utilizing the Louisiana sugar houses for refining raw sugar from abroad in their inter-season periods of idleness without the use of bone-black. In these experiments the "melted sugars are best first clarified with *kieselguhr* . . . "

The diatom is a plant of marked esthetic qualities as well as of much practical value and scientific interest, though unfortunately these cannot be appreciated without the aid of a microscope. The writer for many years exhibited each year a microscope slide less than a quarter of an inch square; this small square was divided into one hundred smaller squares and in each of these reposed the skeleton of a diatom and under each was written its long technical name; often as many as twenty letters. Yet the admiration of the students was always divided between the minute technique of the maker of the slide and the beauty and variety of the forms exhibited. There are over 10,000 known varieties of these artistic forms. Often the siliceous cover is ornamented with very fine lines, sometimes 125,000 to the inch, so that in the past they were used to test the fineness of high power microscope lenses.

The remains of diatoms are known most abundantly as beds of rocks composed largely of their remains and go under the name of diatomaceous earth, infusorial earth, and *kieselguhr*. They are accumulating today on the bed of the oceans, and in many lakes, as in some of the lakes of Maine where their remains when dredged out dry into a beautiful pure white, flour-like substance of great purity. But such details have no place here. Neither have questions of the money value of the product, though it is perhaps necessary for the sake of leaving a correct impression to say that the value of the raw material produced in the United States is not great at the present time. Fortunately, this country has large resources of material which can be drawn upon as necessity demands.

This, then, is the case for the diatom; these the grounds on which are asserted your interest in a plant you did not know. The evidence would seem to be valid, for when the National Research Council found that diatom research was not adequately supported in this country—in fact was practically unsupported—and attempted to obtain funds to endow such research, the funds were forthcoming and are now being most advantageously utilized.

A NATIONAL INFORMATION SERVICE FOR SCIENCE AND TECHNOLOGY

By Ruth Cobb, Research Information Service, National Research Council

The Research Information Service of the National Research Council, a busy exchange for scientific knowledge, begins its third year with increased financial resources and with the determination to double its scope and output. Already it has relieved some investigators of the drudgery of routine compilation and irksome thumbing through a mass of literature by telling them what they want to know when they want to know it. It has also relieved them of the annoyance of answering repeated questions about themselves and their work by collecting the facts once and for all to pass on to those who ask. By protecting the specialist from interruptions to his constructive research it is saving the razor edge for finer work than cutting wood.

One way in which the Information Service is increasing its value to the research worker is by the preparation of lists of published and unpublished bibliographies. This "bibliography of bibliographies" on subjects connected with all of the natural and applied sciences lists manuscripts, card indexes, periodical catalogues and abstracts, books and authors' appendices to monographs. If scientists will appeal to the Service for the bibliographies they need before compiling their own, reference lists now in existence will be more often consulted and much unnecessary work will be saved.

The Service is also constantly making surveys for the collection of such information as will be of use in answering the inquiries that are put to it in steadily increasing number. Whenever the information so collected is of sufficient interest and importance to justify wide distribution, it appears as a circular or bulletin of the Council. As the natural sequence of such surveys there has been published a list of the doctorates conferred in 1920 by American universities and a list of periodic technological and scientific bibliographies, abstract journals, and systematic handbooks that are issued at home and abroad. Usually the information in these bulletins becomes the beginning of a permanent file which is corrected and enlarged at every opportunity. When there is sufficient demand the original bulletin is brought up to date and a new edition appears. There is now in preparation a second edition of *Bulletin of the National Research Council*, No. 2, which will give the name of the director of research and some information about the staff, research work, and equipment of about 500 laboratories in industrial establishments of the country. Similar records for several hundred academic and private laboratories are also on file.

The Service has other informational files of records which it is not feasible to publish. Accounts of some 12,000 of America's leading scientists and a special war-time group of chemists and mining engineers listed by the Bureau of Mines may be consulted through the Service. These records are being brought up to date, supplemented, and so classified that individuals meeting any reasonable specifications may be easily selected. Facts about investigations in progress are continually noted, but because of the difficulties met with in actively seeking data of this kind and keeping them current, the file is far from complete. It is being gradually perfected, however, as the other activities of the Service develop.

A bulletin on funds available in 1920 in the United States for the encouragement of scientific research has just been issued by the Council. It gives an account of medals, prizes, grants and research scholarships and fellowships amounting in value to something like thirty-six million dollars annually. With this as a nucleus, an up-to-date file of information on research funds is being developed. The Service is also listing the principal working sources which it discovers for each type of scientific information. In this source file are included other informational bureaus, individuals, selected industrial, academic and federal laboratories, special libraries, and independent research institutions. It is used by members of the staff as a starting place in answering questions on a great variety of scientific subjects.

Through the "miscellaneous request service," information about all kinds of scientific and technological activity is sent to those who seek it. Questions are answered concerning research problems, projects, work in progress and results; methods and processes; laboratories, equipment and apparatus;

*See *Journal of Industrial and Engineering Chemistry*, Feb., 1921, p. 150.

publications, funds and personnel. There is no charge for replies which do not require a special search; charge for information which calls for elaborate compilation or search through a vast amount of material merely covers the cost of labor.

To carry on this work the Research Information Service has a resident technical staff consisting of its director, Dr. Robert M. Yerkes, six scientific associates and two technical assistants. Each associate is responsible for answering questions which lie within the field of his special interest: physical sciences and engineering, chemistry, geology and geography, biology and agriculture, medical sciences, and anthropology and psychology. Each has also under his direction one or more of the special projects for the whole field of science, such as collecting information about scientific personnel or funds for the aid of research. The technical staff, when necessary, calls upon other resident members of the Council for advice or assistance, or consults with specialists in the federal scientific bureaus.

The Service has among its advisory members, in addition to the chairmen of the various divisions of the Council and a representative from each department of the Federal Government, twenty specialists in widely divergent fields. These members at large include representatives of important industries, leading scientific and technical libraries and educational institutions in all parts of the country.

Through its membership contacts with academic, industrial and federal activities at home and abroad, the Service has access in an unusual degree to the most reliable sources of up-to-date scientific information. As a division of the National Research Council it enjoys the privilege of coöperative relations with the national scientific organizations of other countries. It regularly exchanges informational publications with the British Department of Scientific and Industrial Research and the Advisory Council for Scientific and Industrial Research of Canada, and exchanges information as occasion arises with the corresponding organizations of France, Italy, Japan, Australia, New Zealand and South Africa. This widens the scope of its usefulness to the scientists of America by providing a channel through which they may learn of the plans and accomplishments of science abroad.

The Service wishes and expects to coöperate with many other informational sources now operating in the country, for it believes in utilizing rather than duplicating labor. In cooperation with *Special Libraries* it has just assisted Mr. W. I. Swanton, of the Reclamation Service, in preparing for publication a reference list of 170 Washington libraries. This list gives the location of the library, the name of the librarian, a general account of the subjects covered by each collection of books and the approximate number of volumes. The establishment of a reprint and informational exchange service with the James J. Hill Reference Library of St. Paul, Minnesota, is now being planned. The interests and aims of the two organizations have so much in common that each should be of great help to the other in locating scientific materials and making them accessible through the proper distribution of surplus numbers and the photostating of rare publications.

The Research Information Service does not itself carry on any research work, but it is in close contact with its sources and keeps itself informed about laboratories, institutions and men who are advancing the scientific knowledge of the world.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

SIMPLE RADIO RECEIVING SETS

The radio laboratory of the Bureau of Standards is co-operating with the Bureau of Markets of the Department of Agriculture in the establishment of a system of broadcasting market reports by radio. Since this system has been started, a great many people previously not concerned with radio work have become interested in this subject, and it therefore, seems important to secure all possible information regarding available radio apparatus which is suitable for receiving these reports.

The Bureau of Standards is enlisting the co-operation of manufacturers by asking them to write to it with a view to submitting for test such sets as they manufacture or may develop for the purpose mentioned above. It is likely that a considerable demand for this equipment will develop among farmers, shippers, chambers of commerce, radio clubs, and others who are interested in receiving directly radio market reports. As a result of the investigation now begun by the Bureau, it is hoped that specifications may be prepared covering the requirements as to behavior and usefulness which such sets should meet.

CONFERENCE ON AERONAUTICAL SAFETY CODE

On May 13, a conference was held in Washington to consider the development of an Aeronautical Safety Code for which the Bureau of Standards and the Society of Automotive Engineers have been designated as the joint sponsors by the American Engineering Standards Committee. This conference was attended by representatives of the War, Navy, and Post Office Departments, the National Advisory Committee for Aeronautics, the National Safety Council, Manufacturers' Aircraft Association, and the Insurance Underwriters, as well as representatives of the two sponsors and the American Engineering Standards Committee.

It was the sense of this conference that a safety code ought to be developed without delay and that a committee should be formed at once which would include representatives of all organizations interested in this subject as well as those which were present at the conference. Invitations have, consequently, been extended to other interested organizations.

FOURTEENTH ANNUAL CONFERENCE ON WEIGHTS AND MEASURES

The Fourteenth Annual Conference on Weights and Measures was held at the Bureau of Standards on May 23-26. Invitations had previously been sent to the governors of states, mayors of various cities, and weights and measures officials throughout the country. The governors of those states which do not maintain an office of weights and measures were in every case urged to appoint delegates to the conference and many took advantage of this opportunity to send a representative to the Bureau. Manufacturers of apparatus and persons engaged in weights and measures work for industrial concerns, associations, etc., were also present. Several of the manufacturers had on exhibition various weights and measures appliances, including scales of all sorts, machines for automatically measuring the yardage of cloth, liquid measuring pumps, etc.

The main object of these conferences is to secure uniformity in weights and measures standards and laws and in the enforcement of the latter. Only fundamental questions of weights and measures are considered; the aim of the conference being rather to direct the general subject than to go too much into detail. Among the speakers were Mr. Herbert

Hoover, Secretary of Commerce; Dr. S. W. Stratton, Director of the Bureau of Standards, and numerous officials of State Weights and Measures Departments. The subjects treated included the sale of bread by weight, the detection of shortages, the weighing of coal, and tests of liquid measuring pumps.

STANDARD TESTS FOR AUTOMOBILE BRAKE LININGS

At a conference recently concluded at the Bureau of Standards, recommendations were made for a standard method of testing brake lining materials for automotive purposes; the engineers of the Bureau discussed these recommendations with representatives of nearly all the manufacturers of this class of material, as well as of the Motor Transport Corps of the Army and the Standards Committee of the Society of Automotive Engineers.

In view of the very large quantities of brake lining material used in automotive vehicles to-day, the establishment of standard test conditions which may be used by all makers and large users and which can form the basis for purchase specifications is of considerable importance, not only to the industry but also to the public. Such standards carefully planned tend to bring about a greater uniformity of the materials concerned, and by establishing a better understanding of the essentials leave the manufacturer free from unnecessary restraint in other directions, so that he may use all his energy and ingenuity toward the improvement of the materials and his methods of production.

At the suggestion of the Motor Transport Corps, the Bureau of Standards, about a year ago, undertook an investigation to determine the most suitable conditions for such standard tests, and this conference was called to explain to those most interested the results of this work and to discuss proposals based on these results.

Dr. S. W. Stratton, Director of the Bureau, opened the meeting with a short address in which he dealt with the work of the Bureau in general and referred to the numerous occasions on which the Bureau has been able to assist the industries, by investigating problems of this nature, and by co-operating in the establishment of standards and the preparation of specifications.

Dr. H. C. Dickinson, Chief of the Automotive Power Plants Section, followed with some remarks covering the brake lining investigation in particular and the results that were expected from it.

A full report and analysis of the work was then presented by the engineer in charge of the investigation, who concluded by submitting the Bureau's recommendations for the test as based on the results obtained.

A thorough discussion, during which the experience of many of those present was freely offered, followed and led to a very satisfactory agreement.

The interest of the brake-lining industry in this work was well shown by the large attendance and the thoroughness of the discussion. Many of those present expressed their appreciation of the assistance rendered by the Bureau and the hope that the Bureau, whose activities in the automotive field are only a recent development, would be able to co-operate with this industry to an increasing extent in the investigation of many important problems calling for consideration.

PAPER AND COTTON COMPARED TO BURLAP FOR SANDBAGS

The results of a study which the Bureau has been conducting of paper and cotton bags for use as sandbag fortifications has been published in the Paper Trade Journal for May 19, 1921, under the title "Suitability of Paper and Cotton Bags in Relation to Burlap Bags for Sandbags." This work was undertaken for the War Department and the purpose of the investigation was to determine whether or not these materials could be used satisfactorily in sandbag fortifications or trenches.

The work included a large amount of laboratory testing and also experiments in service to find the value of this material when made up into bags. All tests in this investigation, with the exception of those on wet material, give results which indicate that a rope paper would be a very good substitute for burlap. This paper, however, is very weak when it becomes wet. If it could be waterproofed, this difficulty would be eliminated. However, at the present time the waterproofing of paper is only in the experimental stage. Many formulæ for waterproofing have been patented but when they are tried out in the paper mills it is found that they either do not waterproof at all or destroy the suitability of the paper for the purpose for which it is to be used. Practically all the work on waterproofing to-day has dealt only with the chemical treatment of the fiber, either before or after the paper has been made, while very little has been done on the scientific control of beating processes in the manufacture of paper.

The Bureau plans to investigate this problem thoroughly and by the use of chemicals combined with scientific control of the beating to manufacture, if possible, a paper similar to that mentioned above and yet waterproofed sufficiently to make it suitable in every respect for sandbags.

Since the paper just mentioned contains 80 per cent manila and jute rope stock which might be hard to obtain in time of war, it is probable that the Bureau will also undertake to manufacture a 100 per cent sulphate fiber paper that will be as strong as the above rope paper.

TESTS OF BRAZED COPPER SHEETS INTENDED FOR ROOFING PURPOSES

Recently the Library of Congress submitted for test some copper sheets for roofing purposes which had been joined by brazing. Two types of joints were used, a simple "lap" joint and a "lock" joint in which the edges of the two sheets to be joined were first bent double and then "locked" into one another.

The series of examinations indicated that of the two types of joints, designated as lap and lock, the lap joint is superior in strength and much more desirable in its structure. In forming the lock joint, apparently it is necessary to apply the heating torch for a considerably longer period in order to cause the metal to flow into the joint. In doing this, the upper fold of the sheet which forms the lock is highly heated and often burnt. It was noticed in most cases that none of the brazing metal penetrated directly below the upper fold so that the upper sheet could easily be bent along the line of the junction. It appears from the results of this examination, that if the buckling of the sheets which apparently cannot be entirely prevented with this method of joining sheets, is not too objectionable, the lap joint should be satisfactory for the purpose. The lock joint is decidedly inferior in strength and other properties to the lap joint.

It may be pointed out that the joints should be *carefully* cleaned after brazing. In the specimens submitted the film of zinc chloride remaining after cleaning the specimens was sufficient to accelerate atmospheric corrosion very decidedly within a very short time.

METHOD FOR DIFFERENTIATING AND ESTIMATING UNBLEACHED SULPHIDE AND SULPHATE PULPS IN PAPER

Technologic Paper 189 bearing this title has just been issued and may be obtained from the Superintendent of Documents at 5 cents per copy. The purpose of this paper is to fill a need felt especially by paper chemists and analysts for a rapid and reliable method of distinguishing between and of making an approximately correct determination of mixtures of unbleached sulphide and sulphate pulps.

This paper gives briefly the basic differences in the manufacture of the two pulps and contains a concise review of the methods that have been recommended from time to time for distinguishing between them. It gives the procedure followed

in developing a new and comparatively rapid method for distinguishing between these pulps and also gives some of the more important experiments carried out with various staius during this investigation. The method of preparing the new stain and the method of procedure for differentiating between unbleached sulphide and sulphate fibers is described in detail and tables showing the results of quantitative microscopical analysis of mixtures of these fibers stained by the new method are given.

RULING SCALE BY LIGHT WAVES

It is interesting to note that it is now possible to construct scales for the measurement of length directly from the fundamental wave lengths of light without the use of any intermediary standard. As an example of work of this sort which is now being regularly carried out, it may be mentioned that the Bureau recently completed the rulings on a six-inch scale using light waves from a tube containing Neon (wave length 5800 to 6600 A) as the length standard. The work was done for and the scale has been delivered to the Brown & Sharp Manufacturing Company.

RESEARCH WORK ON ELECTRODEPOSITION

During the past month a member of the Bureau's staff attended meetings of the American Electrochemical Society in the interests of research work on electrodeposition. A great deal of interest was shown in the proposed program and plans were made for the formation of a division of the Society to be concerned wholly with this kind of work. If such a division is organized, it will be a distinct advantage in bringing together persons interested in this field and in so doing it will stimulate research work aloug electrochemical lines.

Letters have been sent out by the National Research Council to about 200 representative manufacturers in whose plants electroplating is an essential process. The purpose of these letters is to inquire whether they would be willing to furnish financial support toward research work on electrodeposition. If such support is received, it is expected that the funds will be expended for research work conducted at the Bureau of Standards under the general supervision of a representative advisory board.

PYROMETRIC PRACTICE

Technologic Paper No. 170, "Pyrometric Practice," is now available. This publication has already been adopted in several universities as a standard text for teaching pyrometry. Copies may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 60 cents per copy.

Research Work of the U. S. Forest Products Laboratory

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

BAKING POWDER AND ARTIFICIAL LEMONADE FROM WESTERN LARCH

In an analysis of western larch the Forest Products Laboratory has found that the wood contains a large quantity of a water-soluble gum called galactan. This gum can readily be turned into mucic acid, which can be used as a substitute for tartaric acid in baking powder and citric acid in artificial fruit flavors. This discovery will soon be put into commercial application by the erection of a plant in Montana for the extraction of galactan from larch. The gum thus obtained will be used in the production of baking powder and in the manufacture of soft drinks.

PLAN CAMPAIGN FOR THE PROTECTION OF MINE TIMBERS

How to get the mining industries interested in protecting more of the wood used in mines against decay is a problem upon which both the Forest Products Laboratory and the Bureau of Mines are now working in coöperation. The problem is not one of testing out preservatives so much as conducting a publicity campaign which will bring to the attention of the mining companies the facts about the tests that have already been made.

At least three preservatives have been found suitable for mine work. These are coal-tar creosote, zinc chloride and sodium fluoride. Creosote is the most effective in preventing decay. Timbers thoroughly impregnated with it are likely to resist decay until they are crushed or worn out. Occasional objectiou is made to the possible fire hazard of creosoted wood, but long experience indicates that the additional fire risk is very small. Zinc chloride and sodium fluoride are odorless, aud if anything they tend to reduce the inflammability of wood. They are cheaper than creosote, and although they do not give such permanent protection they greatly increase the life of timbers. Coal-tar creosote may be applied by the brush, dipping, open-tank, or pressure methods. Zinc chloride and sodium fluoride may be injected by the steeping, open-tank, or pressure methods. The cost and effectiveness of the methods of treatment iucrease in the order given. The saving possible with any of them is so great that it will pay every mine to adopt the use of some preservative on permanently located timbers.

DIRECTION OF GRAIN AFFECTS STRENGTH OF PAPER BOXES

Paper has grain the same as wood has, and the Forest Products Laboratory has found that the strength of a box made of paper or fiber board is affected by the direction in which the grain ruus in the sides, top, and bottom. Fiber boxes are scored at the corners to make them fold without breaking. If the fibers in the paper run so that they lap around the corners, the box is stronger than if the fibers run parallel to the folds. No attention has been paid to this fact heretofore in the manufacture of paper boxes.

WHEN IS THE BEST TIME TO CUT TIMBER?

Many of the theories which have been advanced regarding the durability of wood attribute too much importance to the time of cutting. As a matter of fact, the time of cutting has very little effect upon the durability or other properties if the timber is properly cared for after it is cut. The method of handling logs at different times of the year, however, does influence their durability.

Timber cut in late fall and winter seasons more slowly and with less checking than during the warmer months, and when proper storage or handling is impracticable, winter cutting is best. Fungi and insects do not attack wood out of doors in cold weather, and by the time warm weather arrives the wood is partly seasoned and somewhat less susceptible to attack. It is for these reasons that winter cutting is advantageous, and uot on account of a smaller amount of moisture or sap in the wood in winter, as the popular belief has it. There is practically no difference in moisture content of green wood in winter and summer.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

THE INFLUENCE OF ENVIRONMENT ON SEXUAL EXPRESSION IN HEMP

In the *Botanical Gazette* for March, 1921, Professor John H. Schaffner of Ohio State University presents the results of a series of interesting experiments, covering a period of some years, on the influence of environment on sexual expression in hemp.

The study of hemp, *Cannabis Sativa L.*, was originally undertaken to determine what influence the environment might have on the sex ratio between staminate and carpellate plants.

It soon became evident, says the author, that far more fundamental problems were presented for solution than the mere changing of sex ratios. Intermediate plants appeared, bearing both stamens and carpels. There was also an endless profusion of abnormal flowers involving all sorts of sexual expressions; and, most remarkable of all, complete reversal of sexual expression under the influence of an abnormal environment presented itself as the most interesting phenomenon to be studied.

Professor Schaffner then gives a detailed account of his experiments, the conclusions from which may be summarized as follows:

1. Hemp planted in spring in the open, under normal conditions, developed as pure carpellate and pure staminate individuals. There was no confusion of sexuality.

2. The ratio between carpellate and staminate individuals is about 1:1, with a large deviation in either direction for various plots.

3. Hemp planted in winter in the greenhouse on shallow benches with low light intensity showed great confusion in sexual expression. Abundant irregularities were produced, such as stamens with normal stigmas and structures partly carpellate and partly staminate, as well as more typically bisporangiate flowers and flowers typical of the opposite sexual state.

4. Both carpellate and staminate plants showed reversal in their growing period to the opposite sexual state.

5. In extreme cases 88 per cent of carpellate plants showed reversal to maleness, and 80 per cent of staminate plants showed reversal to femaleness.

6. Both staminate and carpellate plants, although they showed decided sexual dimorphism, contained all the factors and abilities of both sexes. There is no question of a homozygous or heterozygous condition involved. The staminate and carpellate individuals contain the potentialities for the perfect development of the opposite sex. Reversal of the sexual state takes place in the vegetative tissues, and has no relation to a reduction or segregation of chromosomes or their possible hereditary factors.

7. The sexual reversal is of all degrees of intensity, from very imperfect expressions of the opposite organs to completely normal development.

8. Sexuality is a state or condition not Mendelian in nature, but related to the functional activity of the plant and profoundly influenced by environment. Maleness and femaleness in hemp are probably controlled by the metabolic level of the cells, and sex reversal takes place when the metabolic level is decidedly changed or disturbed.

9. Any tissue in its growth may be in a neutral state of varying degrees of intensity; and during its continued growth can pass from one state to the other without any reference to chromosome segregation or combination which are the ordinary causes of Mendelian phenomena.

10. Sex is subject to experimental control in the individual in such dimorphic, diœcious species as hemp, and such control can be exercised in various ways by changing the ordinary factors of environment, and, therefore, presumably also by chemical and physical stimuli of various kinds.

WATER AND SEEDS

In the *Journal of Agricultural Research* for January, 1921, Mrs. George J. Bouyoucos and M. M. McCool of the Michigan Agricultural Experiment Station, present an interesting article on the measurement of the amount of water that seeds cause to become unfree and their water-soluble material.

In introducing their article, the authors say:

It has been shown that soils cause water to become inactive or unfree, as is indicated by its refusal to freeze or to function as a solvent. The magnitude of this unfree water has been measured by means of the dilatometer method, which has proved most convenient, appropriate, and unique for this purpose. The principle of this method is based upon the fact that water expands upon freezing. If the amount of expansion that a certain amount of water (1 gr.) produces upon freezing is known, then the quantity of water that freezes in the soil can be calculated from the magnitude of expansion produced.

It is, of course, very well known that seeds absorb large quantities of water and with a considerable force. Seeds like the lima bean, cowpea, soybean, clover, and alfalfa absorb over 100 per cent of their dry weight of water. The great attraction that seeds have for water is best realized by the fact that they will abstract the moisture from the soils even down to the point of air-dryness. Whitney and Cameron found, for instance, that when 50 gm. of seeds of cowpeas were mixed with 50 gm. of soil containing 15 per cent of water, the seeds had in 12 hours gained 12.1 per cent of water and had left in the soil only 1.3 per cent, that is, the soil was reduced practically to air-dry condition. It appears, therefore, that the power of seeds to absorb water is greater than that of soils.

Since it was found that soils cause water to become unfree, the extent varying with the character of the soil, the question arose whether the seeds also cause water to become unfree, and if so, to what extent.

In order to obtain information bearing upon these questions a general investigation of the problem was undertaken by the authors. The type of dilatometer used and the general procedure followed were the same as those used in the study of soils. The procedure consisted in weighing out carefully about 10 gm. of air-dry seeds and placing them in water to soak for about two days. Then they were taken out, pressed between filter papers in order to eliminate their excess of water, weighed again quickly, and introduced into the dilatometer. The unoccupied space in the dilatometer was then filled with ligroin, and care was taken to expel all the air. The mouth of the dilatometer was then carefully stoppered, and the contents were placed to cool in a temperature of 3° C. When this temperature was attained by the contents, as indicated by the column of ligroin in the stem, which remained stationary, the water in the seeds was caused to freeze. This was accomplished by taking hold of the dilatometer by the stem and moving it gently in the cooling mixture until solidification began, which was indicated by the rise of the ligroin in the stem. The dilatometer was allowed to remain in the cooling mixture with frequent movements until the rise of ligroin in the stem ceased. The total rise of the ligroin in the stem was taken to represent the total amount of expansion due to the formation of ice.

The results of their investigation are then presented in detail and analyzed. They may be summarized as follows: The amount of water that seeds cause to become unfree is very large, varying from 25.05 per cent in broom corn to 76.76 per cent in black soybeans, based on the air-dry weight of seeds. Repeated freezing and thawing tends to diminish considerably the amount of unfree water, especially in some seeds.

Dry seeds contain a large amount of water-soluble material, as is evidenced by the high freezing-point depression. When 10-gm. portions of seed flour are mixed with 20 cc. of water and the mixture is allowed to stand for about 40 minutes or less, the freezing-point depression varies from 0.280° C. in wheat to 1.180° C. in speckled wax beans. At very low moisture content the magnitude of this depression must be very great. The magnitude of the osmotic pressure must also be correspondingly very great.

The great power that seeds possess to absorb water and to abstract it from the soil is partly if not largely due to their tremendous internal osmotic pressure.

THE NATURE OF LIFE AND DEATH

SCIENCE for April 15, 1921, contains an interesting article by Professor W. J. V. Osterhout on the nature of life and death.

Some of the fundamental ideas of biology are extraordinarily difficult to analyze or define in any precise fashion. This is true of such conceptions as life, vitality, injury, recovery and death. To place these conceptions upon a more definite basis it is necessary to investigate them by quantitative methods. To illustrate this Professor Osterhout considers some experiments made upon *Laminaria*, one of the common kelps of the Atlantic coast.

The author finds that the electrical resistance of this plant is an excellent index of what may be called its normal condition of vitality. Agents which are known to be injurious to the plant change its electrical resistance at once. If, for example, it is taken from the sea water and placed in a solution of pure sodium chloride the electrical resistance falls steadily until the death point is reached; after which there is no further change. Study of the time curve of this process shows that it corresponds to a monomolecular reaction (slightly inhibited at the start).

This and other facts lead to the assumption that the resistance is proportional to a substance, M, formed and decomposed by a series of consecutive reactions. On the basis of this assumption one can write an equation which allows us to predict the curve of the death process under various conditions. This involves the ability to state when the process will reach a definite stage, *i.e.*, when it will be one-fourth or one-half completed. This can be determined with considerable accuracy.

This curve is of practical, as well as of theoretical, importance, since it allows one to compare the degree of toxicity of injurious substances with a precision not otherwise attainable. The best way of doing this is to proceed as a chemist might in such cases and express the degree of toxicity by the velocity constants of the reaction (*i.e.*, of the death process) under various conditions.

From this point of view the death process must be regarded as one which is always going on, even in an actively growing normal cell. In other words the death process is a normal part of the life process. It is only when it is unduly accelerated by a toxic substance (or other injurious agent) that the normal balance is disturbed and injury or death ensues.

Putting this into chemical terms, we may say that the normal life process consists of a series of reactions in which a substance O is broken down into S, this in turn breaks down into A. M. B, and so on. Under normal conditions M is formed as rapidly as it is decomposed and this results in a constant condition of the electrical resistance and other properties of the cell. When, however, conditions are changed so that M is decomposed more rapidly than it is formed, the electrical resistance decreases and it is found that other important properties of the cell are simultaneously altered.

Hence it is evident that injury and death may result from a disturbance in the relative rates of the reactions which continually go on in the living cells.

The author then gives the details of his experiments, and concludes:

It is evident that if the facts have been correctly stated such fundamental conceptions as vitality, injury, recovery and death may be investigated by quantitative methods. This leads us to a quantitative theory of these phenomena and a set of equations by which they can be predicted. It may be added that the predictive value of these equations is quite independent of the assumptions upon which they were originally based.

This investigation of fundamental life processes shows that they appear to obey the laws of chemical dynamics. It illustrates a method of attack which may throw some light upon the underlying mechanism of these processes and assist materially in the analysis and control of life-phenomena.

THE DEPENDENCE OF THE FISHES ON THE DIATOMS

IN *Ecology* for April, 1921, Dr. Albert Mann of the Carnegie Institution discusses the Dependence of the Fishes on the Diatoms. In introducing his discussion Dr. Mann says that to make clear the extent of the service the diatoms render in this respect and the opportunity they offer for improvement in fish-culture methods, it is necessary to state a fact, evident enough but easily overlooked, namely, that in the sea as on the land the fundamental supply of all food comes from vegetation; that the elements necessary for life are as hopelessly beyond the reach of aquatic animals as of terrestrial animals; and that fecundity and growth are as rigidly proportionate to the abundance of plant-life in the sea as on the land. In consequence of this, the ocean has its fertile fields and its deserts as unmistakably as does the shore; and when marine plant-life is multiplied, the long chain of animal organisms directly or indirectly feeding upon it shows the same proportionate increase that is seen when all these interrelations are terrestrial.

Continuing, the author says: The diatoms are the great fundamental food supply of the aquatic world. They are the grass of the sea. They people all waters in all latitudes. They surpass in bulk, or annual productiveness, all the other aquatic plants a thousand fold. They are available as food, not only in the shallower waters along the coast, but constitute almost the only prolific form of plant-life in the open ocean. They are so minute as to be available for food for the smallest animal organisms, and yet, because of their abundance, they represent the sole food-supply of some of the larger forms. They are highly nutritious, and not one among the thousands of living species, so far as is known, is deleterious.

The diatoms differ in genera and species in different localities as strongly as do terrestrial plants. Not only are there clearly marked arctic, temperate, and torrid zone diatoms, but the contrast between the local diatom flora of one part of the country and that of another is often very marked. So general is this diversity of each locality, that it is safe to say the diatomist could recognize by a sample its geographic origin as accurately as the botanist recognizes the source of a collection of phanerograms, were our knowledge of the diatoms in different waters as full and accurate as our knowledge of terrestrial plants in different lands. And this fact being established, it is natural to carry the comparison a little further and to wonder if there cannot be some sort of *marine agriculture*, some science dealing with the improvement and multiplication of desirable sea-plants, as we deal with desirable land-plants.

The life-habits of different genera of diatoms fit them for very dissimilar habitats. Some live wholly in fresh-water, others are marine, a few invariably brackish. Many species

are attached and therefore confined to those places where submerged objects afford the necessary foothold. Others live principally or wholly on the bottom and have the power of locomotion. A very large number are pelagic, and either represent the main ingredient of the great plankton life of the ocean or constitute the food of those minute animal organisms, like the copepods, which characterize such planktons. It is evident, therefore, that the kinds of diatoms to be found in any locality, or capable of being introduced there, depend on the particular life-habits belonging to the different species.

Each species also has its seasonal period of growth. This is generally in spring or early summer, but in a few instances the maximum is in autumn. There are a few species that show a biannual increase, the second one being the smaller. In consequence of these differences, the period of the year at which a given species is at its maximum of abundance becomes an important factor in its value as a direct or indirect food-supply for migrating fishes. If it is coincident with the annual arrival of these fishes, or so precedes it as to give rise to a more prolific animal food at the time of arrival, the result will be wholly different from what would follow with diatom species developing earlier or later. There is also great variation in the abundance of certain species in successive years. The controlling factors of this erratic annual variation are at present too obscure to admit of a statement. Undoubtedly along the coast or on the open sea the major factor may be taken to be the annual changes in the great ocean currents and in those surface movements caused by wind and tide. But that these do not suffice for an explanation is proven by the fact that in quiet waters, like inland ponds and streams, the difference in the diatom flora from year to year is sometimes very great.

As the chain of interrelation between the fishes, lobsters, clams, oysters, and other edible sea forms, on the one hand, and the diatoms, on the other, is sometimes one of a single link but more often of many links, it is perhaps worth stating that the dependence of the fishes, etc., on the diatoms is as real in the one case as in the other. Some of our economically important fishes, as the menhaden, are preëminently diatom feeders; but in the very great majority of cases this is not true. A relatively large number include diatoms in their menu during the first periods of life, but soon change to a mixed or wholly carnivorous diet; and there are doubtless a good many that never feed upon them at all. But whatever the food of any species, that food in its turn must be adequately abundant, and can be so only by an ample supply of its particular food. The strength of our chain, regardless of the number of its links, is, then, dependent on that first and fundamental link which joins it organically to the inorganic elements of which all living forms are composed, elements which are unavailable until woven into living tissue on the mysterious loom of the chlorophyll-bearing plant. And this, in the entire aquatic world, is par excellence the diatoms.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

POTASH SITUATION IN GREAT BRITAIN

In the issue of May 12 *Nature* discusses the potash situation in Great Britain and recounts briefly the well-known facts with respect to pre-war potash supplies. In 1913 the consumption of potash fertilizers expressed in tons of potassium oxide (K_2O) shows Great Britain to be the last in the list of named countries in which Germany comes first, followed by the United States, Holland, France, Austria-Hungary, Russia and then Great Britain. The United States used more than five times the potash of any other country save Germany and it is pointed out that many soils actually require less potash than German soils and elsewhere crops, such as potato, which require large quantities of potash, are not grown on so large a scale.

After discussing the efforts to reduce the production of the Alsatian deposits, due to the fact that more German capital was invested in German deposits, and the superiority of these Alsatian deposits, the discussion takes up the possibility of securing adequate supplies for Great Britain.

"In this country the only practically available source of supply is the flue-dust from blast-furnaces. It has long been known that this dust contains potash, but the amount was small, and, worse still, very variable, depending largely upon the working of the blast-furnace. As the result of a number of experiments initiated by Mr. K. M. Chance of the British Potash Company, Ltd., it was discovered that by adding a small proportion of salt to the blast-furnace charge, practically all the potash present could be volatilized as chloride and recovered in the flue-dust. Messrs. Rossiter and Dingley investigated for the above company the percentages of potash in a large number of iron-ores, and published their results in November, 1919, in the Journal of the Society of Chemical Industry. The ores richest in potash are the bedded iron stones of Secondary age, such as those of Northamptonshire, Cleveland, Lincolnshire and Oxfordshire, which showed respectively 0.42 per cent, 0.36 per cent, and 0.30 per cent of potash. When salt is added to the charge of a blast-furnace smelting these ores, flue-dusts are obtained that contain about 30 or 35 per cent of K_2O as chloride or other water-soluble salts. Such dust is, therefore, considerably richer in potash than the ordinary manurial salts hitherto supplied from Germany, and it seems probable that it could be applied direct to the land with very beneficial results, though not much work has as yet been done in this direction.

"The experiment of adding salt to the blast-furnace charge has as yet been tried in only a few works, and the bulk of the dust thus produced appears to have been worked up for potash salts at the works of the British Potash Company, Ltd., at Oldbury. In the paper already referred to, it is calculated that if the salt process were adopted in every blast-furnace in Britain, potash equivalent to 50,000,000 tons of K_2O could be recovered annually. This figure is about double that of the British consumption of potash for agricultural purposes before the war, but falls far short of the amount that we really require in this country, while it need scarcely be said that nothing even remotely approaching it has as yet been produced nor does there appear to be the slightest prospect of reaching it for many years to come.

"In the meantime, British agriculture needs potash and needs it most urgently. Agriculture is the most vital of our industries, and when the process of destroying our coal-mining industry, and with it our manufacturing industries generally, now apparently in full swing, has been consummated, it will be the only means by which the inhabitants of these islands can continue to exist. It would appear, therefore, that the best policy in our national interests is to help our French Allies to develop as speedily as possible the potash resources of their recovered province, and to obtain from them the supplies of potash which our lands, neglected in this respect during the war, so sorely need. Of course, the potash-bearing blast-furnace flue-dust would continue to be worked up, as it is at present, for the manufacture of high-grade salts of potash, and

no doubt it would be able to supply a certain proportion of the British consumption of such salts, and to this extent decrease our imports."

CARBON MONOXIDE

Each year a large number of deaths are caused by asphyxiation, in practically all cases of which carbon monoxide is the direct cause. The gas is colorless and odorless, gives no warning and usually small animals are used as one of the reliable methods for its detection, in quantities sufficiently large to be harmful. The Bureau of Mines has been interested in the perfection of more exact detectors and Mr. C. R. Hoover recently described a new apparatus which appears to be particularly efficient. It consists of a rubber aspirator bulb attached to a six-inch tube so that a sample of air to be tested can be drawn through the tube which contains activated charcoal to remove gases which might interfere with the delicate test for carbon monoxide. The air is forced out through a glass tube containing a mixture of fuming sulphuric acid and iodine pentoxide. In the presence of carbon monoxide this white solid turns varying shades of green which increase the depth of color as the amount of the gas increases. This color is compared with a permanent scale attached to the apparatus so that the quantity of carbon monoxide is readily determined. The test requires but a few seconds and shortly afterward the color disappears from the pentoxide mixture and the other test can be run.

This device has now been improved upon by using a piston and cylinder with valve which replaces the aspirator bulb and so insures a definite quantity of gas for each test. The test material has been rendered more sensitive so that quantities of the gas as small as .3 of 1 per cent can be shown and fairly accurate analyses to amounts up to 2 per cent made within a few seconds. This latest form of protector has been successfully used in coal and metal mines, in holes and stoke rooms of ships, in garages, and in conduit tunnels. The new detector using the piston gives results which check very well indeed with those obtained by exact analytical chemical methods.

CORROSION

The American Electrochemical Society devoted much of its recent meeting to a symposium on the corrosion of metals and alloys. In closing this symposium the following summary of the more important points brought out during the two days' discussion was made:

"(1) Iron or steel containing about ¼ per cent copper will withstand atmospheric corrosion better than iron or steel without copper. (2) Iron or steel containing about ¼ per cent copper, when completely immersed in ordinary tap water or in acidulated water, does not resist corrosion as well as pure iron. (3) In boiler practice and in hot water systems (closed systems) the presence of oxygen greatly accelerates corrosion; the removal of this oxygen practically eliminates corrosion. (4) Carbon dioxide in boiler water, together with soluble iron, causes corrosion, and the removal of the CO_2 practically eliminates corrosion. (5) Other elements added to iron in well-defined amounts tend to reduce corrosion, but detailed investigations have as yet not been reported. (6) A satisfactory co-ordination of alloy corrosion research needed but lacking.

"Fink also made the following suggestions for future study and research: (1) A thorough investigation of the surface film involving careful determination of the chemical and of the physical properties of this film—*e.g.*, chemical composition, porosity, tenacity, coefficient of adhesion, coefficient of expansion, etc.—as compared with those of the underlying metal. (2) A careful study of the microstructure of the metal near the surface and a similar study of the metal directly underneath the surface film. (3) The effect of chemical and mechanical treatment on the surface film and the underlying metal. (4) A more complete micrographic investigation of the surface changes of metals during the process of corrosion. (5) A better classification of corrosion phenomena—for example, we must define the limits of moisture and salts in air in which the tests were made. (6) A standard of measure of corrosion."

SMOKE IN SALT LAKE VALLEY

For some time certain smelters in the Salt Lake Valley have been under investigation with respect to whether or not the smokes and fumes from them constitute a nuisance to humans and a detriment to crops. These investigations by scientists were undertaken at the instance of a court and as a result of the scientific report the smelters have been permitted to continue operations under conditions as laid down by the scientists. The results have been discussed in *Chemical and Metallurgical Engineering*. It is interesting to note that comparatively few of the analyses show an hourly average of more than one part of sulphur dioxide per million in the samples of air covering some six months during which time upward of four thousand determinations were made.

The average human adult who is already acquainted with the odor of sulphur dioxide will first be able to detect it at a concentration of from 3 to 3.5 parts per million. Those not acquainted with the odor could probably detect it when the concentration reaches from 4 to 5 parts per million and above that figure until 10 parts per million are reached. The action is usually sufficient to cause most people to feel slight discomfort or to cough. Occasionally short whiffs of less than five parts per million cannot be considered a nuisance to any one but continued breathing of air containing even slightly more than 5 parts per million would probably cause discomfort. A few breaths of 10 parts per million would probably be called a nuisance by most people even if this concentration occurred only at considerable intervals.

The entire record of atmospheric tests amounted to nearly six thousand single determinations showing only 19 without concentration of 3 parts or more per million and only one concentration of 6 parts per million. The highest concentration ever found in the district was 7.6.

It is believed that the more sensitive crops when weather conditions are favorable to sulphur dioxide action cannot endure such concentrations as have been found in the field without severe burning and certain remedial steps have been suggested. The principal one of these is that the temperature of the roaster gases before they are discharged into the air should be markedly increased. No measure appears to be anywhere near so efficient as this one in remedying an unfavorable field condition. Should this alone prove insufficient a tall stack will probably have to be erected in addition to heating the gas. The removal of dusts is also an important consideration in which bag filtration and electrical precipitation are employed. The following is quoted:

"The operative measures which should receive attention are:

"1. The bag-filtration of the blast-furnace gases.

"2. The electrical precipitation of roaster dusts and other suspended solids by means of the Cottrell installation, two of the three units of which have been in regular operation

"3. The discharge of the roaster gases, which carry the highest concentrations of sulphur dioxide, at a temperature high above that of the outside air. During the dormant season for plants the temperature of these roaster gases was increased, and incidentally their volume as well, by the delivery of the boiler gases from a neighboring power house directly into the main exit stack. During the season of plant growth the gases were heated by means of coal furnaces near the base of the stack.

"4. The discharge of the gases from roasting operations from a high stack at a point approximately 455 feet above the ground level.

"5. A maximum daily elimination of sulphur from roasting operations amounting to about 100 tons.

"Industrial plants such as this are complicated and sensi-

tive organisms. They will not run themselves. Their successful operation from the standpoint of a high recovery of metal at a low cost of production requires that painstaking attention be paid to all factors which have to do with the efficiency and cost of smelting operations. The situation is not now different in regard to smelter operation in relation to smoke injury. With the recent development of remedial measures having to do with plant operation a new responsibility has been thrust upon the operating staff, a responsibility which calls for no less skilful and painstaking attention on their part.

"It can scarcely be denied that this plant is a potential agent of injury. Allow the filtration bags to deteriorate, reduce the voltage in the Cottrell plant, neglect the measures which have to do with maintaining a relatively high temperature in the exit gases, and a discharge of lead and arsenic in objectionable amounts or of sulphur dioxide under conditions of concentration and temperature which could give rise to serious injury to crops might easily result."

FISH GLUE

No other glue has as many or as varied uses as has liquid fish glue. The best grade of fish skin glue is the only satisfactory one for the production of half-tone plates. It is also used in the production of single line plates for photoengraving work. Fish glues are nearly always used where great flexibility is required, such as in adhesive plasters and book binding. They are sometimes blended with hide glue and considerable quantities find their way into sizing operations. This gives stiffness and yet a degree of flexibility. Dr. T. K. Tressler in the May issue of *Chemical Age* (New York), writes popularly on the manufacture and properties of fish glue in which it is pointed out that the quality of glue prepared from the so-called ground fish which include cod, haddock, cusk, hake, and pollock, is higher and the yield greater than in the case of glue made from most other fish. In general the glue stock is first freed from salt by continuous washing, after which it is cooked slowly and the glue liquor drawn off for further treatment and concentration. Fish heads are treated by a somewhat different process from that used for fish skins and the details are regarded more or less as trade secrets. Fish head glues are generally made opaque with a white pigment. The following properties are given by Dr. Tressler:

"The color of liquid fish glue depends upon the nature of the raw material, the method of manufacture and the clarity of the product. Fish-skin glues, as they are ordinarily produced, are the clearest. Fish waste and fish-head glues are more or less opaque. Most clear fish glues make a dark joint when used with light-colored woods, and consequently much of the liquid glue on the market contains some white pigment. This gives the glue a lighter color and also makes the joint less conspicuous.

"The odor and taste of fish glues depend largely upon the nature and amount of preservatives and essential oils added. Upon heating for some time, the essential oil is driven off and the true odor of the fish glue becomes more apparent.

"The 'speed of set,' or the time elapsing after the application of a coat of glue until the glue becomes a gel, depends upon the gel point and viscosity of the liquid glue, the amount of glue applied, the nature of the wood, and, also, to some extent, upon the humidity of the atmosphere. 'Setting' is caused by a partial withdrawal of the moisture in the glue, thus causing the gelling of the liquid glue. The higher the viscosity and gel point of the liquid glue, the less the amount of glue applied, the more absorbent the surface to which the glue is applied, and the lower the temperature and humidity of the atmosphere, the more rapidly does the glue 'set.'

"At any given temperature and humidity the rate at which the fish glue dries depends upon the source of the glue, the method of manufacture and the salt content. As a rule, fish-skin and waste glues dry more rapidly than fish-head glues, although if the fish skin and waste glues contain an abnormally high salt content this may be reversed.

"The viscosity of liquid fish glue depends upon the source of glue, the method of manufacture, the percentage of dry glue in the liquid glue, the temperature, and the addition of substances other than fish glue, *e.g.*, boric acid, hard glue, phenol and cresol. The addition of boric acid increases the viscosity of liquid fish glue to some extent; whereas the addition of phenol and cresol decreases the viscosity. Small amounts of hard glues, *i.e.*, animal glues, sometimes are added to increase the viscosity.

"Fish-head glues are usually more flexible than skin and waste glues. Glycerin and glucose often are added to increase the flexibility of glues.

"Properly preserved liquid fish glues will keep indefinitely in an air-tight can or well-stoppered bottle. If the glue is stored in a cold room it will gel. This gel melts quickly as soon as the glue has been warmed above its gel point. When liquid glue containing phenol or cresol is put up in tin cans, after a time a black ring is formed around the top of the can where the phenol or cresol has attacked the iron. However, this does not injure the quality of the glue. Precipitates sometimes settle out from poorly prepared liquid glue, but this settling does not injure the strength of the glue."

A COPPER IRON MAGNETIC ALLOY

Mr. B. H. Bennetts in the May issue of *Mining and Metallurgy* contributes the following information concerning a copper iron magnetic alloy found by him in sampling black copper.

"While sampling a shipment of 50 tons of black copper, by the templet method, we found a pig of copper which we tried for two days to drill. It was so hard that it was impossible to drill the hole even with special drills or with the usual press drill. This aroused our curiosity and made us determine to get some of this alloy, which we accomplished by planing away the copper from the segregation. It had the following composition.

	Per Cent
Copper	14.51
Cobal and nickel	2.21
Iron	56.13
Silicon	3.00
Manganese	4.28
Zinc	5.96
Phosphorus	0.21

A shortage of the alloy would not allow further investigation.

"The copper from which this alloy was obtained was made from ores that had a wide range of minerals. Perhaps it will help the reader to say that the copper comes from blast-furnace work making two products—black copper and high-grade copper matte.

"Another curious feature of this copper is the fact that it can be lifted with a magnet. Some samples of the black copper possess this property to a higher degree than others even when the black copper has the same copper content. My attention was first called to this when I tried to clean the copper from any steel that may have entered while drilling the sample for assay purposes. The copper has an average composition of about 92 per cent copper, 2 per cent sulphur, silicon, iron, and, what I consider very unusual, some phosphorus."

SYNTHETIC EMERALDS

The *Chemical Bulletin* for May reports that "Mr. David Fahlberg of Chemical Engineering, in coöperation with one of his students, Mr. P. C. Kelley, has developed a process for making artificial emeralds. The product seems to be equal in quality to the natural emeralds. It has an index of refraction identical with that of the latter and a hardness greater than that of quartz. The process involves the fusion of crude beryl with a mineralite at high temperatures for several days."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME METHODS OF OBTAINING ADJUSTABLE SPEED WITH ELECTRICALLY-DRIVEN ROLLING MILLS

After outlining the speed requirments of steel rolling mills, disclosing the need in many cases for adjustable speed over a wide range, the paper goes into a discussion of the merits of the Scherbius system of speed control, both single range and double range, in which the slip energy of the main motor is returned to the system as electric energy. A comparison is made with the Kraemer, or synchronous converter system, in which the slip energy is returned to the main motor shaft. The superiority of the Scherbius system is particularly apparent at speeds near synchronism, as over this range the synchronous converter of the Kraemer system becomes unstable. The double range Scherbius system permits of satisfactory operation at speeds below synchronism, at synchronism, and above synchronism. This range is not practicable with the Kraemer system.

The author enumerates the following factors which are to be considered in making a choice of a control system. The more general conditions having a bearing on the choice are: range of speed control, frequency of supply circuit, maximum load at all speeds, production of mill at different speeds, and whether the control is to be automatic.

The double range Scherbius system can readily be designed to meet all except the most extreme speed ranges for both 25-cycle and 60-cycle supply circuits, while the Kraemer system is rather handicapped if the supply frequency is 25 cycles.

When automatic control is required the direct-current systems with motor-generator will usually give better results.

There are, however, a number of important advantages in favor of the double range Scherbius system which must be considered in making a choice. They are: (1) Generally higher efficiency and correspondingly lower power consumption throughout the entire range of control. (2) Frequently a considerable part of the output of a mill may be rolled by the motor without the regulating set, due to the motor speed falling intermediate between the upper and lower limits of the range. This is a very great advantage over the any single range system, since in the event of the failure of the regulating set the high speed at which the roll motor with single range control runs non-regulating limits the production of the mill to small sections while the regulating equipment is being repaired. (3) Its cost is usually lower than that for the other systems when compared on the same basis, *i.e.*, range of speed control over which the maximum roll motor loads may be carried without the roll motor becoming unstable. (4) In common with other systems a large number of speed points may be provided, the power-factor of the main motor may be raised, and the equipment is thoroughly reliable and readily maintained by the operating department.—K. A. Pauly, *General Electric Review*, Vol. 24, pp. 422-432, May, 1921.

WASTE PREVENTION IN THE ELECTRICAL INDUSTRY

During the present industrial crisis some relief from the prevailing depression may be obtained by a careful investigation of the capacity and potential efficiency of the manufacturing plant in the works. Mr. E. V. Chambers suggests several ways of effecting considerable economies.

Of great importance is the steam boiler efficiency. To-day coal is three or four times its 1914 cost, therefore a saving of 10 per cent in the fuel consumption means a considerable annual saving in dollars and cents. The author suggests the employment of intelligent stokers and the carrying out of a complete boiler efficiency test which would expose the defects in the system. He also discusses the importance and the methods of obtaining the proper feed water, the elimination of boiler scale and methods of proper steam piping.

Some electrical manufacturing establishments are equipped with producer gas plant; some of these plants produce tar and sulphate of ammonia, while other plants produce tar only. There has not been any satisfactory demand for this tar, but lately a new form of tar still was introduced, which is of continuous type. The author gives the details of such a plant which gives light oil, heavy oil and pitch. It is quite possible that the products of distillation of producer tar, particularly in the case of the smaller distillation plants, can be utilized in the same works as that which produces the tar. The pitch can be readily converted into a quick drying, hard black varnish, which is eminently suitable for painting castings, pipes, steel plates and other manufactured electrical products. As a general protective paint for the shops and buildings it cannot be excelled. The oils can be utilized for cleaning purposes, particularly for the removal of grease. They also provide for fuel for oil-fired furnaces, and the heavier quality can be easily converted into disinfectant

Many valuable products are wasted by the discharge of liquids used in the electrical and associated industries. Such solutions usually consist of metallic salts with or without the presence of free acid. The electrolytic methods of metal recovery, particularly copper, are, of course, well known. In many other cases the evaporation of surplus water in waste liquor will result in a liquor which, on cooling, deposits crystals which may be recovered for re-use. Care should be taken in regard to the selection of suitable apparatus, particularly where acids are concerned. An excellent material for resisting acid solutions is fused silica. As an example of the recovery of useful products from waste liquors, the author describes an installation for recovering hydrochloric acid and ferrous sulphate from iron wire cleaning or pickling.

Lubricants after a time become so saturated with impurities that they are discharged as waste. By submitting these waste oils to the action of centrifugal force in a rotating centrifugal machine the suspended solids are almot instantaneously removed from the oils, which are discharged in a perfectly transparent condition, quite suitable for re-use. The author describes and illustrates such a centrifugal machine and its modifications for oil recovery from metal turnings and for removing water from lubricating oils.

Quantities of waste mica cuttings are produced in the various sections of the electrical industry. Hitherto these materials have been treated as waste; these cuttings have been examined, and it has been found that on the average they contain the following: mica 70, shellac 24, moisture, 6 per cent. By submitting these cuttings to the ordinary solvent extraction process, it has been found that the whole of the shellac can be recovered, and that the small mica plates free from the shellac can be used for building up large insulating sheets, by using the recovered shellac as the adhesive and paper as the carrying base. In several establishments proposals are under consideration for recovering these materials for re-use in the works. Shellac can also be recovered from insulated paper cuttings.

There is much to be said for the institution of a special inspector whose duty it should be to prevent the various forms of waste. This waste department should investigate every process which could be applied to the recovery for re-use of what has hitherto been regarded as unavoidable waste.—*Electrician* (London), Vol. 86, pp. 619-622, May 20, 1921.

THE ELECTRIC STRENGTH OF AIR UNDER CONTINUOUS POTENTIALS AND AS INFLUENCED BY TEMPERATURE

In view of the ever increasing transmission voltages, this paper is of importance. It describes a series of experiments on the influence of temperature on corona-forming continuous potentials. The observations have been made on three sizes of wire of diameters 0.0251 cm., 0.0803 cm. and 0.0933 cm., and in each case at several values of temperature within the range of 5° C. and 70° C. At each temperature the pressure has been varied from a value in the neighborhood of that of the atmosphere downward, reaching in the extreme cases the value 6.03 cm. of mercury. Within the range of values reached, as indicated above, the general form of the law of corona, as developed experimentally by a number of other observers, is found to be fulfilled. There are separate families of curves for positive and negative potentials as obtained by varying the pressure for each constant value of temperature.

The critical surface intensity at which corona started upon the wires can be summarized by the relation.

$$E = 39.8\delta + 10.35 \sqrt{\frac{\delta}{d}} \quad \text{for + corona}$$

$$E = 40.3\delta + 11.96 \sqrt{\frac{\delta}{d}} \quad \text{for — corona,}$$

where $\delta = \frac{3.92P}{T}$ P being the pressure of the gas in centimeters of mercury, and T the absolute pressure in degrees centigrade. The observations thus show that under constant conditions as to pressure and temperature a higher value of negative potential than positive potential is required to form corona.

As plotted graphically, the results seem to indicate that when larger wires are used corona appears at the same values of both positive and negative potential. The observations, however, have not been extended sufficiently to show this identity of value. This conclusion is at variance with the observations of a number of other experimenters, in particular with those of W. S. Brown, who concludes that with larger values of diameter of wire negative corona may appear at lower values than positive corona.

The experiments substantiate the empirical laws developed by Whitehead and Peek, although the constants of the equations involved are higher than any heretofore observed. There are indications that at temperatures in the neighborhood of 70° C. a departure from the empirical laws mentioned may set in.—J. B. Whitehead and F. W. Lee, *Journal of the American Institute of Electrical Engineering*, May, 1921, pp. 373-387.

GIGANTIC COLORADO RIVER PROJECT

An application for a preliminary permit to develop the energy from the waters of the Colorado River has recently been accepted by the Federal Power Commission. The Colorado River is considered the second largest river system in the United States and is unique among the important waterways of the world in its adaptability to control for the four-fold purpose of flood prevenion, irrigation, navigation and power development.

The application contemplates the development of the Colorado River above the Bowlder Canyon project, at Marble Canyon and Diamond Creek, but does not consider the possible power development in the Grand Canyon and other sites along the National Park. The possibilities of the Colorado River project may be summarized as follows: (1) Three thousand feet of waterfall will produce 4,350,000 horsepower, which is equal to one-half of the total hydro-electric power now generated in the entire United States. (2) Flood control will be absolute, reducing the water discharged to that volume which may be safely carried within the natural banks, levees being practically eliminated. (3) Provision will be made for irrigation of an additional 3,250,000 acres, of which one million acres will be above the canyons and the balance below. (4) The storage basin will be over 200 miles in length, impounding more than 40,000,000 acre-feet of water. This will involve the construction of a dam many feet higher than the highest dam in the world. (5) Four hundred miles of the river will be made navigable. (6) The area which may be served with power includes three-quarters of the State of California; the entire States of Arizona, Nevada and Utah, more than one-half of Colorado and New Mexico and one-fifth of Idaho and Wyoming, with possibly large areas in Northern Mexico. (7) Power may be used for the electrification of steam railroads, as well as for commercial agriculture, mining and municipal uses in the entire district. The saving in fuel oil by the substitution of this hydro-electric power will amount to 90,000,000 barrels per year, which is practically the present annual production of the entire State of California. (8) These savings in oil consumption will indefinitely extend the fuel life of our navy and merchant marine, which during the war were of necessity changed from coal to oil burning. (10) Ninety-three per cent of the run-off may be impounded above the storage dam, which will be 500 feet in height. (11) The increase in community wealth by this development will be equal to the total valuation of California for the year 1920.

Below is given a comparison of the proposed Colorado River dam with the present great dams of the West:

Dam.	*Location.*	*Height.*	*Storage.*
Elephant Butte......	New Mexico	318 feet	2,638,836 acre-feet
Arrow Rock.........	Idaho	438 feet	280,000 acre-feet
Roosevelt...........	Arizona	280 feet	1,367,300 acre-feet
Colorado (proposed).	Arizona	500 feet	40,000,000 acre-feet

—*Journal of Electricity*, January 15, 1921, Vol. 46, pp. 60-61.

MOUTH-OF-MINE SUPER-POWER PLANTS

According to the *Electric Journal* of May, 1921, it was found that the greatest central station development during 1921 has been in the Pittsburgh district, where two super power plants, each designed for an ultimate generating capacity of 300,000 kw., are being placed in service with accompanying extensive increases in transmission lines and substations. Each of these new plants is located on a river affording sufficient condensing water. In addition, they are examples of the mouth-of-mine type of station, as each is located adjoining large coal fields controlled by the power companies. Such locations are desirable from two viewpoints. They eliminate the necessity of paying a profit to coal mining and transportation companies, and afford added insurance of continuity of service, as there is no possibility of interruption of the fuel supply due to strikes or other difficulties on the regular transportation lines. There is also the further possibility of increased economy due to the continuous use of a uniform grade of fuel whose characteristics can be thoroughly analyzed by the operating forces; whereas with purchased coal it is necessary to make use of whatever fuel the railway or water transportation companies are able to deliver.

The central station industry as a whole is vitally interested in the development of these mouth-of-mine super-power plants with their transmission systems and methods of interconnection; therefore, the papers contributed by the officials of the Duquesne Light Company and the West Penn Power Company to the *Electric Journal* of May, 1921, will be found of considerable interest. G. H. Gadsby, vice-president of the West Penn Power Company, discusses the industrial field of his company, while G. G. Bell gives a complete illustrated description of the generating system of the same company. After briefly describing the Connellsville and Windsor stations, the author devotes the major part of his paper to the description of the new Springdale station. In addition to the advantages outlined above, the outstanding features of the recent West Penn

system may be summarized as follows: (1) The labor required for the handling of coal and ashes is reduced to a minimum. (2) Motor drive is used for auxiliaries, thus reducing maintenance and simplifying the station construction. (3) Auxiliaries and sources of power are provided with duplicates, thus eliminating to a great extent shut-downs resulting from troubles with the small equipment. (4) Clean water is provided for service use and distilled water for boiler use. (5) Air for boilers is handled in such a way as to prevent condensation and the formation of vapor in the ash pits. (6) Excessive air is eliminated from the feed water, thus reducing corrosion in boilers as well as in the economizers, if the latter are installed later. (7) Cranes or trolleys have been installed over practically all auxiliaries to reduce to a minimum the time of making repairs. (8) Switching equipment of the highest capacity obtainable is installed. The switches for the electrical equipment were especially designed to give large rupturing capacity, and provisions are made to cut out any switch in case of accident or for inspection. The doors for the oil switches and disconnecting switches are interlocked to prevent an attendant from working on any circuit which is in service.

The power stations of the Duquesne Light Company are described by J. M. Graves. The bulk of the paper is devoted to the new Colfax power station.

TELEO CEMENT FOR MULTI-PART HIGH-TENSION INSULATORS

Many multi-part insulators fail after four to six years of service. The failure has been traced to cracks which form in the insulator heads. It has been repeatedly shown that these cracks were not occasioned by electrical or external mechanical stresses, but were found to be due to inequality in expansion when heated between the porcelain part and the uniting cement. The stresses thus caused were mathematically investigated by Meyer and Donath in the *Elektrotechnische Zeitschrift*, No. 16, 18, 24 and 45 of 1919. The cracks develop gradually, and do not usually lead to line failures until some abnormal condition arises, or the insulator head is split right through. It is probable that the cement during the first few years of the life of the insulator possesses a certain elasticity, and only attains final hardness after some time.

The Hermsdorff Porcelain Works have now succeeded in discovering a cement mixture which possesses the same expansion coefficient. This has been patented under the name of Teleo Cement, and the process of its manufacture consists in adding to the cement a thinning medium which has a lower coefficient of expansion than porcelain until the required equilibrium is obtained. A thinning of cement to Teleo compound in the ratio of ½ to ¼ is generally sufficient for this purpose. The thinning mediums hitherto in use only gave a slight reduction of the expansion coefficient with increasing thinning. The comparatively high specific gravity of these thinning materials made it impossible to use greater thinning than 1:3 to 1:3, but even greater thinning than mentioned above is quite permissible with Teleo. Its expansion values as compared with those of porcelain and the usual cement are given below:

MEAN EXPANSION VALUES

Material	Observer		
	Laboratory Standard	Hermsdorf Porcelain Works	Freiberg Porcelain Works
Porcelain	3.5×10^{-6}	4.7×10^{-6}	11.0×10^{-6}
Sand Cement	13×10^{-6}	13.1×10^{-6}	4.4×10^{-6}
Teleo Cement	4.0×10^{-6}	5.2×10^{-6}	5.1×10^{-6}

The use of Teleo does away with the necessity of interposing an elastic coating between the cement and the insulator, which practice was resorted to when the danger occasioned by their unequal expansion was first recognized.—Dr. Weicker, *Elektrische Kraftbetriebe und Bahnen*, Vol. 18, pp. 277-278, November 14, 1920.

FUSED BASALT AS ELECTRIC INSULATOR

Recently attempts have been made to melt basalt and to cast it in various forms, and above all to make from it insulators which may with advantage take the place of glass and of porcelain. Basalt is a rock of igneous origin, and can be melted, but hitherto it has not been found possible to make it keep its natural properties during solidification. The difficulties appear now to have been overcome by Dr. Rible de Maurice of Auvergne, who formerly showed, in 1909, the possibility of melting basaltic rock at a temperature of about 1300° C.

The electric resistance of basalt constitutes one of its most noteworthy properties, and if the practical results justify the hopes, founded on the experimental results already attained in two great French industrial laboratories, a great development will take place in the technics of insulation. The tests were carried out on rock fused without special precautions, and also on casts not destined for electrical use, and yet the behavior of the basalt surpassed that of insulating substances usually adopted in electrotechnics. The high value of the electrical resistance of basalt is due to the fact that during cooling a natural layer is formed on the surface of the basalt which differs essentially from that got in the case of porcelain in that it extends progressively into the substance of the material and does not undergo foliation. The formation of this natural envelope results from a modification of the crystalline structure of the basalt in the neighborhood of the boundaries of the casting. Other precious characteristics of this fused rock are its resistance to the effects of varying temperature, the possibility of forming during fusion the necessary metallic armatures and its greater resistance to deterioration.—*Ingegneria Italiana*, December 2, 1920—through *Technical Review*.

THE RUSS ELECTRIC FURNACE

Mr. E. Fr. Russ describes his new electric furnace in *Elektrotechnische Zeitschrift* for January 13, 1921, p. 34. It can be employed for all purposes requiring electrically generated heat, including the melting of copper, aluminum and other similar metals and alloys, as well as for melting and refining of iron and steel and for the production of various ferro-alloys and special steels. In the usual form of the arc furnace there is a creeping upward of the electric arc; this is prevented in the Russ furnace by the design of the upper electrode. Instead of being in the form of a carbon rod or cylinder of equal diameter above and below the furnace crown, it terminates in a head which is much larger than the shaft which passes through the furnace roof, and this terminal of the electrode nearly covers the whole area of the furnace bed. This arrangement also helps to retain the heat generated by the arc in the metal by checking the radiation toward the furnace crown. The life of the furnace roof is thereby greatly increased, with a considerable saving as regards renewals and maintenance cost. The opening in the furnace roof through which the electrode shaft passes can also be made much smaller with the Russ type of electrode, and the action of the hot furnace gases upon the material of the shafts at this point is consequently much diminished. The electrode shaft is covered with a heat-resistant covering which serves still further to diminish the heat losses at this point. The distance between the electrode head and the surface of the bath is also much smaller than in the usual type of arc furnace, and a more uniform and steady heat effect is thereby produced. The shaft of the electrode is of copper; therefore, the resistance losses are far lower than with the ordinary carbon or graphite electrodes. This new furnace is being manufactured by the firm "Rheinmetall" in Düsseldorf. The article is accompanied by one drawing of a 150-kg. furnace designed for operation with single-phase current.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

"SILENT RECORD" INTERNAL COMBUSTION ENGINE

Description of an engine built by a British concern and working on somewhat unconventional lines. Essentially the engine is a two-stroke cycle. Fig. 1 shows the arrangement of a two-crank engine. The cranks are at 180 deg. to each other and are connected to the charging pistons C and D. These large pistons carry above them four working pistons A_1, A_2, B_1 and B_2. As the working pistons are about half the diameter of the charging pistons, the net area of the latter is about equal to that of the former. There is also a piston valve worked by the eccentric E. The action is as follows: On the down stroke the pistons C and D draw in explosive mixtures which are compressed on the up stroke and delivered to the inlet ports at the bottom of one of the working cylinders, the exhaust escaping through exhaust ports at the bottom of

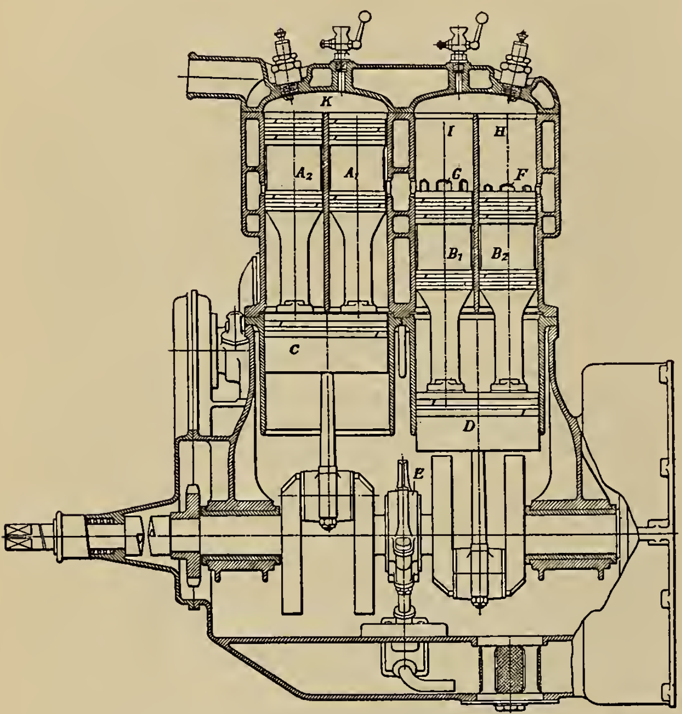


FIG. 1. "SILENT RECORD" TWO-CYCLE ENGINE OF UNCONVENTIONAL DESIGN

the other cylinder. The charging cylinders do not supply the working cylinders directly above them but those above the opposite crank, *i.e.*, C supplies B_1, B_2 and D supplies A_1, A_2.

Taking Fig. 1 in the position shown, the pistons A_1, A_2 have compressed the working charge into the combustion chamber K ready for firing. The charging piston C has also drawn in a charge and slightly compressed it in the space between the pistons. The pistons B_1, B_2 have finished their working stroke and B has fully uncovered the exhaust port G, while B_2 slightly later uncovered the inlet port F. The piston valve now allows the charge compressed by the charging piston C to flow through the inlet port F into the cylinder H from which it flows across the combustion chamber and down the cylinder I, pushing the exhaust out of the port G in front of it.

The charge in the combustion chamber K is now fired, and the pistons A_1, A_2 descend. As they do so the piston valve puts the space above C into communication with the carburetor and allows new mixture to be drawn in, while it puts the space above D into communication with the inlet port uncovered by the piston A_2. The charge in H and I is compressed and fired at the top of the stroke, while the piston A_1, A_2 uncover exhaust and inlet ports corresponding to F and G, and the cycle recommences.

As compared with the ordinary two-stroke cycle engine, the advantage of the design described above lies in the fact that crankcase compression is not used and also that positive distribution of the mixture to the charging cylinders is secured. It is also claimed that a more complete stratification is secured.

The engine shown has four working cylinders equivalent to two cylinders 3 in. x 3½ in. and develops 10 b.hp. at 1600 r.p.m. —*Engineering*, Vol. 111, No. 2888, May 6, 1921, p. 565.

A MODERN AIR LIFT PUMPING PLANT

By John Oliphant

Description of an air lift pumping plant installed by the Philadelphia & Reading Co. at Telford, Pa. In this case the problem was to deliver the water from an artesian well into an elevated tank located at a distance from the well and to control the operation as to starting and stopping from another distant point, and at the same time to control the cooling water supplied to the water-jacketed air cylinder of the compressor, the pumping being at the rate of approximately 100 gallons per minute.

The well was equipped with a 3-inch air lift foot piece having outside air connections and a multiple orifice mixing tube located centrally in the mixing chamber and discharging the air through a number of small openings into a relatively thin sheet of ascending water. It is claimed that this design secures a complete emulsion of air and water in the foot piece.

In the pit around the low head and connected to the reduction pipe was located a Sullivan cyclone booster 30 inches in diameter by 30 inches high. The combined air and water was discharged into this booster and separator near the top and at one side at a tangent to the periphery under high velocity from the well, causing it to swirl and thus effect a perfect separation of the air and water. The water leaves the separator at the bottom, also at a tangent to the periphery and the air passes off at the top. The air pressure in the booster is controlled by a valve set to maintain the pressure required by the head against which the booster is discharging, this head being caused by friction in the pipe (536 feet of horizontal run, a rise of 14 feet from the booster to the base of the elevated tank, and the elevation of 66 feet). The arrangement of the compressor, air receiver and well is shown in Fig. 2. In addition to this the original article contains an interesting drawing showing the pipe layout for the air lift.

The regulation as installed here is of considerable interest. As it was required to control this plant from a distant point, it became necessary to unload the compressor when it stopped, and in starting, to permit the compressor to get up to speed before the load was thrown in. This was accomplished by means of a flyball governor on the compressor that acted as an unloader when it was at rest, and did not admit air to the compressor until the speed had elevated or extended the controlling balls. It was also necessary to shut off the cooling water to the air cylinder when the compressor was stopped, and turn it on again when started. This was accomplished by placing a balanced solenoid valve of the normally closed type in the cooling water line controlled from the starting control at the switchboard.

A push button, together with a relay, were located at the pumping station. In the railway station, 3,600 feet from the

plant, another push button was installed and an electric-connected pressure gage at the base of the plant tank was connected to a bell at this latter point to give the alarm when the tank was full of water. Provision was then made for starting and stopping the plant either at the pumping station or at the station 3,600 feet away. As the compressor is of enclosed, splash lubrication type, and is equipped with

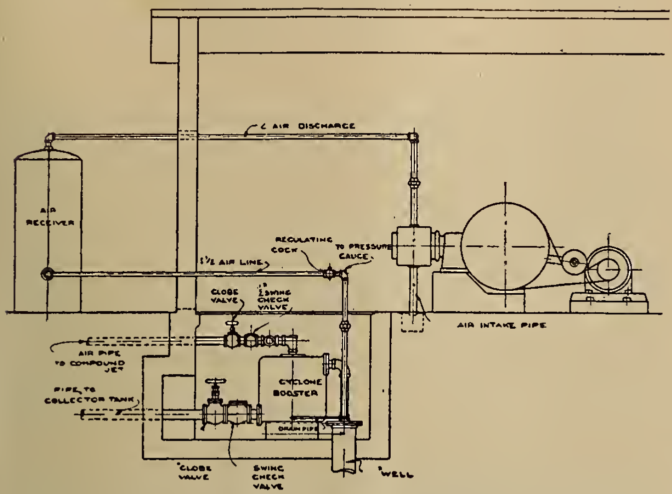


FIG. 2. THE COMPRESSOR, AIR RECEIVER AND WELL IN THE AIR LIFT PUMPING PLANT OF THE PHILADELPHIA & READING CO. AT TELFORD, PA.

a McCord force-feed lubricator, it is safely manipulated from the station, where a push of the button by the station agent starts the pumping and when notified by the ringing of the bell that the tank is full another push stops it. The air and water lines were laid so as to drain back into the booster, and a small connection with a partially opened valve was made from the bottom of the booster back into the well, so that all connections drain to obviate freezing in cold weather during idle periods.

A record is given of a test run from which it would appear that with a total head of 149 feet the theoretical horsepower required was 3.55 hp. while the actual electrical input was 12.5 hp. which would indicate an overall efficiency (wire to water) of 28.5 per cent.—*Railway Maintenance Engineer*, Vol. 17, No. 5, May, 1921, pp. 172-174.

EXETER ROTARY PUMP

THE Exeter rotary pump built under the Feuerheerd patents is an application to pumps of the principle of the square hole drilling device in which a triangular bit functions inside a restraining square formed of equal size. The irregular spaces increasing and diminishing in volume as the two rotate together are utilized to admit and eject the fluid.

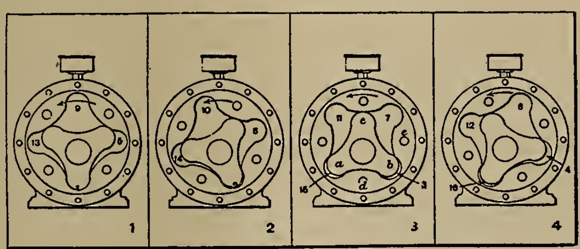


FIG. 3. CYCLE OF MOVEMENT OF THE ROTORS OF THE EXETER PUMP

Fig. 3 shows the cycle of movement of the rotors of the Exeter pump. One of the interesting features is that the pump is self-priming. It has, of course, no valves. As there are no surfaces rubbing against each other, this pump may be used to handle dirty and gritty water. The capacity of the pump per revolution is equal to three times the volume of space 9 in column 1 of the illustration.—*The Nautical Gazette*, Vol. 101, No. 19, May 7, 1921, pp. 597 and 609.

ACTION OF INTERNAL STRESS ON TOOL STEEL

By J. NEIL GREENWOOD

DISCUSSION on the failure of metals through the action of internal stress irregularities, with special reference to tool steels. The opinion is advanced that internal stress falls into two main classes, namely, distortion of the equilibrium space lattice by cold working, and suppression of an allotropic change as a result of rapid cooling. In the case of pure iron the change from the α form to the γ form is accompanied by a volume contraction of about 0.5 per cent. With the introduction of carbon another change takes place due to solution of iron carbide at and above 725 deg. cent., accompanied by transformation of the solvent iron to the γ state. This is associated with a volume change, which increases with the carbon content. The expansion due to solution of the carbide, however, does not equal the contraction due to the formation of γ iron even with 1.5 per cent carbon present. With 0.8 per cent carbon or more, the contraction is approximately half of that due to the α to γ transformation in pure iron. The compressibility of steel is calculated as 0.62 x 10^{-6} per megabar, or 0.945 x 10^{-4} per ton per square inch. In other words a pressure of one ton per square inch causes a diminution in volume of 0.009 per cent; so that an external pressure of at least 50 to 60 tons per square inch would be required to cause a contraction equal to that resulting from the transformation from the α form to the γ form. A contraction of volume also occurs when α cementite is transformed into β cementite at about 200 deg. cent., but this contraction is very slight and only becomes appreciable in comparison with the other changes, when there is about 2 per cent carbon present. In the process of hardening carbon steel internal stresses may be caused by the retention of iron in the γ form with a tendency to revert to the α form by the suppression of the carbide phase change when this compression is accompanied with decrease in volume, and by the completion of the carbide phase change in the interior of the mass.—*Engineering*, Vol. 111, No. 2887, April 29, 1921, pp. 535-537.

PNEUMATIC TRANSMISSION OF MESSAGES ON WARSHIPS

DESCRIPTION of pneumatic dispatch equipment extensively used on British warships.

Fig. 4 shows diagrammatically the layout of a ship installation. There are two electrically-driven pumps situated respectively in the fan room and on the lower deck, and controlled from the main and auxiliary wireless telegraph offices. Each valve has a reversing valve fitted above the silencers, by means of which the message pipes are put into connection either with the suction or pressure sides of the pipe, so that the message carriers may either be drawn from the far end of the tube or propelled in the opposite direction.

On the suction side there is an intake consisting of a simple bell-mouthed casting covered with wire gauze at the open end. The silencers are galvanized steel vessels with internal baffle plates and are introduced to eliminate the pulsations of the air and deaden the sound of the exhaust.

The pumps in smaller installations have a vertical single-acting cylinder, 6 inch bore by 4 inch stroke, running at 600 r.p.m. and driven by a 1¼-b.hp. motor. In larger installations horizontal pumps of a somewhat different type are used.

The brass tubes in which the condensers or carriers travel are of 1½ inch internal diameter and are made in lengths of about 15 feet, the bands being of standard radius of 5 feet with a minimum radius of 1½ feet.

The type of carrier employed has an end pad of hard felt and a body of fiber. A light steel finger spring is fitted inside to prevent the papers being carried from falling out. The felt pad fits the tube and forms a piston against which the air pressure works.

The layout of Fig. 4 shows that a single transmission tube is carried from the installation in the main wireless telegraphy

room to the bridge, and that tubes are carried from the auxiliary wireless telegraphy room to the main wireless telegraphy room and the bridge. On the tube leading to the bridge there is an intercepter in the signal distributing office which consists of a sliding sleeve with a celluloid window and a valve or stop worked by a handle so that the carriers

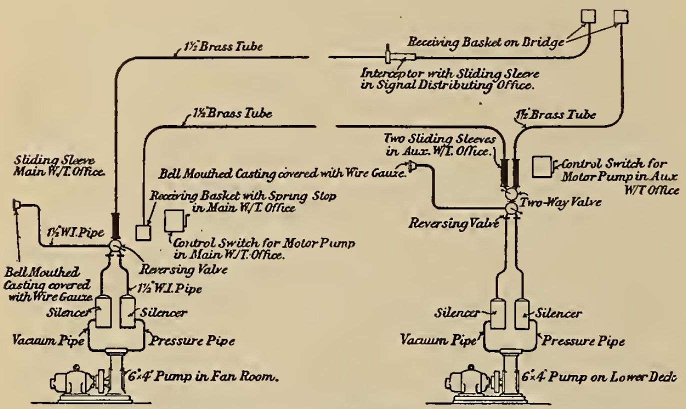


FIG. 4. PNEUMATIC TRANSMISSION OF MESSAGES ON WARSHIPS (DIAGRAMMATIC LAYOUT)

may either be stopped or allowed to pass through as desired.

The whole of this pneumatic dispatch arrangement is simple and there is little or nothing to get out of order. It is very quick in operation and the time of transit on the longest tube on board ship is rarely more than 10 seconds. (The speed at which the carriers travel in the tubes is approximately 30 m.p.h.) The original article describes also some of the secondary details of this apparatus. *Engineering*, Vol. 111, No. 2888, May 6, 1921, pp. 548-549.

PULSATING WINGS FOR AIRPLANES

By Harry Harper

An attempt to describe the theory and action of the wing claimed to have been invented by Prof. Raimund Nimfuhr of Vienna. It is stated that a full-sized load-carrying airplane is to be built and that the venture is to be financed by American capital.

In the Nimfuhr method an attempt is made to imitate the pulsating action of an insect's wing and it is stated that the Nimfuhr wing is hollow with air bags inside, the underneath section of the wing taking the form of a flexible membrane. This membrane can be set beating or pulsating by the action of pneumatic pumps which alternately fill or empty the air bags in the wing. These pulsations, immensely rapid, act powerfully on the cushion of compressed air which, in flight, is formed beneath the plane. It is claimed that these pulsations would not only sustain but also propel a machine forward through the air, the air screw being eliminated entirely.

The Nimfuhr wing is also provided with flexible extremities at both ends, which, by pneumatic action, can be made to extend or contract in imitation of the "reefing" of a bird's wing. (*Motor Transport*, Vol. 32, No. 843, April 25, 1921, pp. 442-443.) *It may be mentioned in this connection that an unsuccessful attempt to build an airplane with pulsating wings was made in 1908 by a Russian engineer, Tatarinoff, working with the Russian War Department. In that case the pulsations of the wing were to be produced by means of springs.* —Editor.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

GEOLOGY OF THE NAMMA COAL FIELD, BURMA

By Edel Moldenke

The most promising lignite deposits are in the Namma field, in the Northern Shan states of Upper Burma, about 30 miles south of Lashio, 750 miles north of Rangoon. The most promising part of the basin is about 11 miles long and 5 miles wide, with an area of 50 square miles. The field was first explored in 1891. In 1906 a few test pits were put down and an unsuccessful locomotive test was made by the Burma railway from coal taken near the surface. In 1918-1919, a careful exploration made by the writer, for the Burma Mines, Ltd., resulted in proving considerable of the bed which was opened in 1919 by a double-track slope to a depth of 500 feet; it has since been extended to 750 feet. The outcrops are few in the gently sloping country, with about 10 feet of soil cover; but sufficient outcrops were found along the main stream of the Namma River and on small side streams to prove the location of the coal.

The basic rock of the coal field is limestone of Devonian age, the coal being found in overlying Tertiary beds. The limestone is gently folded but badly shattered in some places.

There are two main beds: the upper one from 10 to 15 feet thick, with an average of 12 feet, has a characteristic parting about the middle from 3 to 6 inches thick; the lower bed ranges from 19 to 40 feet, is of uniform character from top to bottom and has an average thickness of about 21 feet in the area examined. The stratum between the two beds is loosely cemented sandstones and clays, and maintains a thickness of 21 feet. Below the lower bed is a layer of quicksand 2 feet thick, which is heavily charged with water.

The coal is badly weathered at the surface, but below surface influence it is a lustrous bright black lignite with a dark brown streak, having a specific gravity of 1.4 to 1.5. The coal breaks with a conchoidal fracture. On exposure, it loses some moisture and breaks into cubical fragments. It burns with a bright flame and strong odor and yields a light coke.

The writer considers 50,000,000 tons of coal in the lower and 30,000,000 in the upper bed, a very conservative estimate of the contents of the proved portion of the basin. As no mining has been done, the possible percentage of recovery has not been determined.

The mines would probably be worked by Chinese labor from Yunnan, as the local inhabitants, the Shans, fail to see the necessity for hard labor, and do not form a reliable working force. Owing to the low efficiency of labor and the costly transportation, the cost of coal will be high, but, it is believed, considerably less than that of imported coal.—(Abstract of Paper to be presented at the Wilkes-Barre meeting, September, 1921.)

FLOTATION OF PYRITE

By Walter S. Morley

This paper is a record of the first of a series of tests on sulfide minerals to be made by the metallurgical department of the University of California. The purpose of the tests recorded is to determine the action of standard oils, oil mixtures, and modifying agents on the flotation of pyrites. The commercial value of pyrite was not considered. Of the many factors affecting flotation, only two—the oil and the other agent used—were made variable.

TESTS ON MOUNTAIN COPPER PYRITE

In the tests on Mountain copper pyrite, twenty-two standard flotative agents were used. The pyrite was crushed to pass a 100-mesh Tyler screen and was mixed with clean siliceous sand in the proportion of one to three.

The test samples gave the following analysis: iron, 10.59 per cent; sulfur, 11.95 per cent; copper, 0.16 per cent; zinc, 0.32 per cent; insoluble, 73.60 per cent. By calculation, the pyrite content was found to be 22.40 per cent.

Some of the flotative agents, particularly those containing viscous ingredients like coal tar, practically failed in this investigation. When 0.15 per cent of sulfuric acid was added to the four flotation agents that gave the best results in the preceding tests, there was a tendency to produce a cleaner concentrate and a higher recovery and to decrease the amount of oil necessary. The addition of sodium hydroxide has produced beneficial results. Lime is not a desirable addition. Bleaching powder acts like sodium hydroxide and sodium sulfide; it is essentially a gangue lifter.

Flotation agents that gave good results on fresh material, gave poor results on material that had been exposed to the atmosphere for six months.

TEST ON CHESTATEE PYRITE

These test samples were prepared in the same manner as those described and gave the following analysis: iron, 11.34 per cent; sulfur, 12.07 per cent; copper, 0.37 per cent; zinc, 0.40 per cent; insoluble, 70.65 per cent. By calculation, the pyritic content was found to be 23.60 per cent. Pentarco No. 350 gave a higher grade concentrate of pyrite, but a lower recovery than with Mountain copper pyrite; the recovery of copper is higher and that of zinc lower than before. Pentarco No. 400 gives almost the same grade of pyrite concentrate, but a higher recovery than with Mountain copper pyrite. The addition of sulfuric acid gave better results than the use of these flotation agents alone. But on the whole, the results of these tests, while similar to those obtained when testing Mountain copper pyrite, were not quite so good.

TESTS ON SULPHUR MINING AND RAILROAD PYRITE

These test samples, which were prepared in the same manner as the others, gave the following analysis: iron, 8.84 per cent; sulfur, 7.79 per cent; copper, 0.13 per cent; zinc, 0.21 per cent; insoluble, 81.44 per cent. By calculation, the pyrite content was found to be 14.20 per cent. The results obtained compared favorably with those obtained in the preceding tests. In every case but one, the recovery of pyrite was over 90.0 per cent. The addition of sulfuric acid was of no advantage.

SUMMARY OF RESULTS

Of the twenty-two standard oils and oil mixtures, only four, Pentarco Nos. 350 and 400, acid sludge, and mixture A gave recoveries above 90 per cent, when tested on Mountain copper under the conditions given. Considering both concentration and recovery, mixture A gave the best result. The recovery of zinc, as sphalerite, is generally higher than that of either pyrite or chalcopyrite, using the standard oils and oil mixtures tried.

The recovery of copper, as chalcopyrite, is variable; the highest recovery (93.2 per cent) was obtained by the use of X cake and X ylidine in alkaline solution. This reagent at the same time gave much lower recoveries for both pyrite (47.9 per cent) and zinc (71.0 per cent), thus indicating possibilities of differential or selective flotation.

Sulfuric acid was by far the most efficient of the modifying agents used; the increase in the concentration of pyrite is particularly noticeable. Sodium silicate was somewhat effective in causing a differential or selective flotation of copper, as chalcopyrite from pyrite by keeping pyrite from floating. Sodium hydroxide and sodium sulfide gave, in most cases, a distinct separation of sphalerite from chalcopyrite; *i.e.*, a high copper and low zinc by suppressing the flotation of sphalerite.

Tarnish on the Moutain copper pyrite tended to prevent flotation. Sulfuric acid was the most effective modifying agent in removing the tarnish and giving good recoveries of the pyrite, copper, and zinc.

The finer the material the greater is the percentage of recovery; the pyrite should pass at least a 170-mesh screen in order to get efficient flotation under the conditions of the tests.—(Abstract of Paper to be presented at the Wilkes-Barré meeting, September, 1921.)

UNDERGROUND MINE DEVELOPMENT, ITS DEFINITION AND VALUATION

By John B. Dilworth

The word "development," as used in connection with mining, is a rather general term and in most instances must be qualified or explained before the exact thought in the mind of the user is made clear. But, as a rule, when the development of an individual mine is spoken of the idea in mind is the system of underground workings by means of which the mineral is recovered and transported to the surface. It is this character of development that is considered in this paper.

The discussion is confined to the ordinary room-and-pillar system of mining practically horizontal coal seams that is used in most bituminous coal mines in this country, and to only two phases of this subject; *viz.*, what is properly included under the head of "development" as it appears on the books of a coal company or the inventories of an examining engineer, and how its "value" should be determined by the accountant or engineer.

Perhaps the majority of mine accountants would agree that the mine development account is that capital account which shows the extraordinary expenditures incurred in opening and expanding the underground workings of a mine until it has reached its normal production. The expenditures are those made for shafts, slopes, rock tunnels, drift mouths and such relatively permanent work; also payments over and above ordinary mining costs made for driving entries, air courses and breakthroughs; for timbering, grading haulageways, etc. Yet this definition does not express the universal practice and is subject to various interpretations.

One common departure from this rule is with regard to the period of the mine's operation when the development account should be closed. Some think this account should be closed not when the mine has reached its normal production but when the returns from the coal produced equal the cost of production. Others prefer to limit the development period to the time when the output has reached a certain percentage (say 25 or 50 per cent) of the anticipated normal production. But the best practice would seem to be to continue the development account until the mine is prepared to afford a production that it may reasonably be expected to maintain over a period of years.

ITEMS THAT FORM EXTRAORDINARY EXPENDITURES

It is generally agreed that the total actual cost of such work as the sinking of shafts, driving of rock slopes or tunnels and construction of drift portals should be charged to the mine development account, as it is a more or less permanent nature comparable to plant construction and installation. These will be referred to hereafter as Class A expenditures.

But when preliminary work intimately connected with the recovery of coal is involved and where the outlay is partly or wholly offset by income, from the sale of this coal, opinions differ as to how much of the expense is properly chargeable to development. Examples of such expenses are, compensation over and above the regular room rate paid to miners for coal from narrow places such as entries, air courses, cross cuts, and room necks; yardage paid for removing rock, bone, or other non-commercial material from roof or floor of the seam in such places in the regular course of mining to provide suf-

ficient head room; extra payments made for driving entries through clay veins or local rolls, etc. These will be called class B expenditures.

Expenses of an intermediate nature between classes A and B are those of grading haulage entries by cutting through rolls in roof and floor; driving entries through zones of thin, impure, or faulty coal; timbering or otherwise securing a safe roof in entries; constructing brattices, overcasts and air doors. Some operators maintain that the development account should be charged with the entire cost of all such work during the development period and credited with receipts from the sale of coal produced, the difference being the cost and value of development. While this method, in a sense, shows the net cost of the work, it will rarely give its true value, for the selling price of the coal varies with market conditions and bears no direct relation to the value of development. Thus, the development account of a mine opened during a period of high coal prices would show a much lower net charge than this account for a similar mine opened when coal was cheap.

Another method charges to development all payments above the room rate made for narrow work, yardage and other operations in class B. It assumes that all mining expenses over and above the cost of room coal during the development period are for additions or improvements to the mine and therefore chargeable to this division of the capital account. This method, while preferable to the preceding one, allows too great a profit on the tonnage sold by placing its cost at that of the cheapest coal that the mine affords.

The best method seems to be to charge to the development account all work in classes A and B during the period of development and credit it with the normal cost of the coal recovered. The debit balance, when the development period is passed, will be the net cost or value of mine development. By *normal cost* is meant the product of the number of tons recovered multiplied by the average cost of producing a ton of coal when the mine is in full operation, comprising expenses of mining, dead work, hauling, tipple, ventilation, drainage, power, superintendence, and such items as constitute regular expenses of mining. It may be claimed that this practice involves the use of an estimated figure, normal cost per ton, in the case of a new mine. But this is not a serious objection for, in the case of most coal mines, an experienced engineer or operator, given the wage scale, can estimate quite closely what this cost will be.

CLASSIFYING AND VALUING MINE DEVELOPMENT

Some accountants give a fixed value per foot to the main entries alone or to special parts of them; others classify the entries according to their condition and use and assign a separate per-foot value to each class; still others calculate that it costs a certain amount to develop a working face and give the product of this figure by the number of active faces as the value of the mine's development.

A better plan is to use the method of estimating the excess cost of underground work over normal mining costs for the period of development; *i.e.*, until the workings have sufficient active faces to afford the mine's normal output.

SUMMARY

The period of a mine's development terminates when the active workings are sufficiently large to afford the normal output for which the opertion is designed. The development account should show on the debit side the expenditures incurred in opening and expanding the underground workings during the development period, and on the credit side the normal cost of the coal produced during that period and a proper depreciation allowance. The value of development at a given period is the debit balance of this account; *i.e.*, the net cost or extraordinary expense of underground work incident to establishing a mine on its normal production basis, less depreciation based on the remaining recoverable coal.—(Abstract of Paper to be presented at the Wilkes-Barre meeting, September, 1921.)

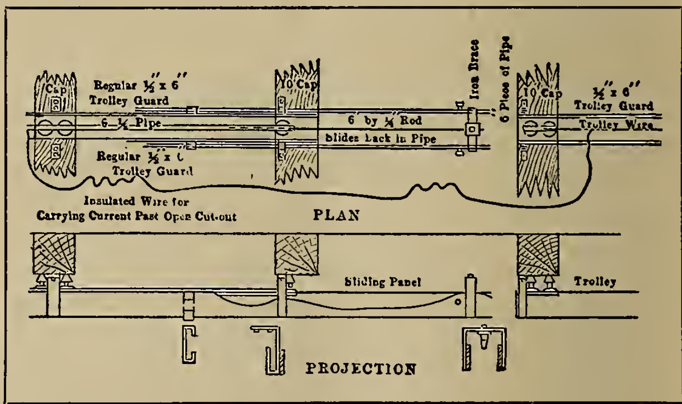
SAFETY CUT-OUT FOR TROLLEY WIRES AT LOADING CHUTES

By E. D. Gardner

Trolley lines used in connection with electric haulage in mines are a source of danger. Usually the wires in metal mines are sufficiently guarded to prevent men from touching them with their persons or with pieces of steel which they may be carrying on their shoulders, while walking along the level, but it is difficult to guard effectively the wires at loading chutes along the haulageways, and in spite of safeguards, chute trappers have been electrocuted through loading bars accidentally touching the trolley line.

To overcome this danger the Calumet & Arizona Mining Co., at Lowell, Ariz., formerly used a hinged V-shaped trough made of 1 inch by 6 inch lumber, that was dropped over the wire in front of the chute, when the cars were being loaded. This arrangement interfered with the easy operation of the chute and a cut-out device for the trolley line was devised by W. R. Gibson, chief electrician for the company. This cut-out is efficient, easily constructed and does not interfere with the operations at the chutes or with the motors operating on the same level. When the cut-out is open the electric current is carried past the gap by an insulated wire on the opposite side of the drift. A hinged board drops down over the ends of the trolley guard when the slide is open and prevents anything touching the live wires. About ninety of these cut-outs are now in use in the mine.

The levels under the stopes are timbered with drift sets placed 5 feet apart, and the loading chutes take up the space



TROLLEY SAFETY CUT OUT

between two sets. All trolley wires in the company's mines are carried 6½ feet above the rails and guarded by two ½ by 6-inch boards placed on either side of the wire.

The cut-out is simple in construction, and consists essentially of a section of ¼-inch rod that slides back into a 6-foot length of ½-inch pipe, both of which are a part of the trolley line.

When closed, one end of the rod remains in the long pipe, at the set back of the chute, and the other end fits into a 6-inch length on the set ahead, and both ends have enough bearing to make proper electrical contact. Standard electric equipment is used in the mine and as the trolley-wire hangers will not fit the ½-inch pipe, a ¼-inch rod is welded on top for clamping it in place. The motors run past the cut-outs with no interference.

When the cut-out is closed, it is guarded by two ½-inch by 6 inch boards, as elsewhere. The free end of the rod and guard boards are fastened together by an open rectangular piece of ½-inch by 3-inch iron. The trolley rod is hung from the top of the iron by insulated hangers, and the guard boards are bolted to the sides. The boards slide back in brackets outside of the regular guards. Occasionally, in wet places, enough current leaks through the insulators to the boards of the cut-out to shock a man, and, to prevent this, insulated knobs are placed on both guard boards for handling.—(Reports of Investigations, Bureau of Mines, Serial No. 2248.)

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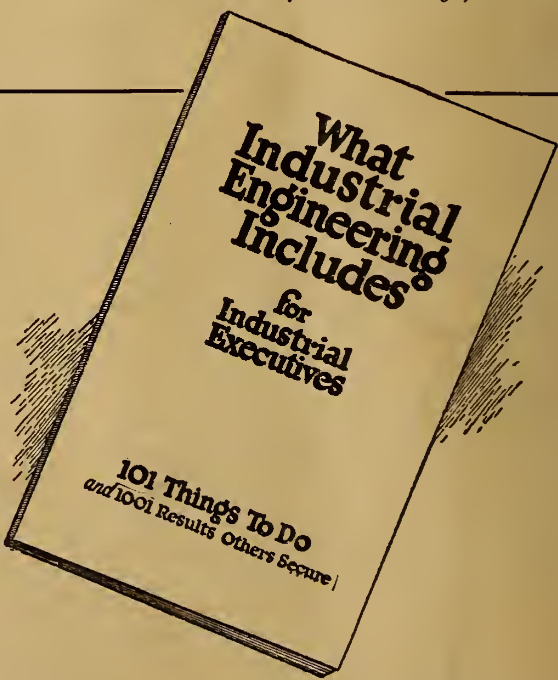

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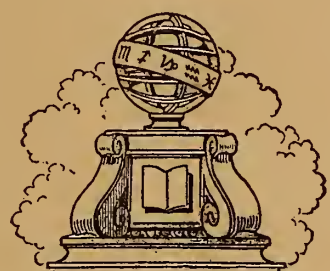

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FLOWER-LIKE FAUNA OF THE SEA—A CASE AT THE AMERICAN MUSEUM OF NATURAL HISTORY INGENIOUSLY DESIGNED TO REPRESENT TWO INCHES OF SEA BOTTOM AS VIEWED THROUGH A MAGNIFYING GLASS (SEE PAGE 129)

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THE FAR FLUNG LINE

One of the most gratifying signs that the world is really settling itself into normal conditions in spite of the reverberations of the great conflict which still assail our ears, is to be found in the resumption of scientific exploration. The far flung line of savants whose fight is to gain knowledge extends through every country on the globe and embraces men of learning from all the centers of civilization. These men are single-minded in the pursuit of knowledge—they have no thought to exploit the native tribes whom they encounter, but merely to study their ethnical character, their habits and their traditions. Gold and diamonds interest them less than geological structure. The lion and elephant are hunted by them not for ivory or pelt, but that they may examine and describe them.

We take pride in the fact that American men of science are conspicuously active along such lines, and because of the liberality and far-sighted enterprise of the great institutions which support their efforts.

Under the auspices of the American Museum of Natural History, Mr. Roy C. Andrews has already established a base of operations in China for his great enterprise of extended research, particularly along anthropological and paleontological lines in the heart of Asia. The entire work is expected to require some five years, and the work of the first year of preliminary organization and preparation is already well under way with the coöperation of the Chinese Geological Survey.

Mr. Carl E. Akely, the distinguished African explorer and animal sculptor, will represent the same admirable institution in his expedition to the Lake region of Central Africa for which he departs sometime during the present month with the express purpose of making a study of the living gorilla in its native haunts. In an article in the present number a résumé is given of our present knowledge of this great man-like ape, which is the closest relative of man among the simians. Undoubtedly we may expect to have our knowledge greatly enlarged as a result of Mr. Akely's observations.

Mr. C. Wm. Beebe of the New York Zoological Park has recently returned from a fruitful and extended visit to British Guiana, where he made a special study of bird life. In an article in this issue on Four-Legged Birds, a delightful passage from a recent book by Dr. Beebe is quoted.

The picturesque Island of Trinidad was visited this spring by a party headed by Dr. Britton of the New York Botanical Gardens and much valuable material was obtained, which is now being studied and classified.

Dr. Rusby of the New York College of Pharmacy is now in Bolivia and expects to make an extended stay in South America searching for and studying medicinal plants.

Thus we may rejoice that once more the sword and buckler of Mars have been dropped for the aegis of Minerva.

RADIANT ENERGY

During the past three or four years many and illustrious have been the visitors who have reached our hospitable shores. Princes and potentates, statesmen and diplomats, famous men of science, and noble women devoted to the cause of humanity have come to seek our aid and to lay the tribute of their heart-felt gratitude at our feet. But among the great of the earth who have thus honored us and been honored by us, none to our mind is more significant than the frail and gentle woman whose genius and patience, together with those of her husband, the late Pierre Curie, gave to the world a new element, so unique in character, and of so mysterious a potency that even now we do but glimpse the revelations to which it is the magic key.

Mme. Curie reached New York City in May for the express purpose of receiving in person the gift of one gram of radium presented to her by the women of America to enable her to continue her valuable researches upon radioactivity, both from a purely scientific point of view and with reference to its therapeutic powers.

It is not too much to say, perhaps, that in future eras this 20th century of ours may be known as the Age of the Discovery of Radium. And the torch lit by the labors of this unassuming but gifted woman has already lent its flame to many another wayfarer along the paths of scientific research. Mme. Curie has had enthusiastic disciples not only in France but in England, America, Germany, Italy and Switzerland. This magazine has given an account from time to time of the work done by Rutherford, Soddy, Perrin and others in the prolific field of the nature and potentialities of radioactive energy. We should like to call especial attention to an article by Professor Perrin in the present number. He has studied with avidity the work done along these lines by his predecessors and contemporaries, tested their theories by his own observations with regard to fluorescence, and arrived by a brilliant process of ratiocination at the startling theory that the atom, so far from liberating energy upon its disintegration, actually absorbs it. And as a corollary to this he boldly suggests that the phenomena observed may be due to radiations of shorter wave length than any which we have thus far been able to demonstrate and describe. He suggests further that the source of these rays, which he ingeniously terms the ultra-X-rays, may be the "ardent center of our earth itself," finding a logical justification of his theory in various facts observed by himself and other investigators in the realm of physics and chemistry. We must leave our readers to judge whether or not he has proved his point, but we can promise them a half hour of keen enjoyment, since, unlike too many men of vast scientific attainment, this brilliant Swiss scientist possesses the art of setting forth even highly abstruse ideas with fascinating lucidity and charm.

GENERAL VIEW OF THE SITE OF TELL EL-AMARNA, WHICH IS BEING EXCAVATED

Excavations at Tell El-Amarna

The Pacifist Pharaoh and the Beautiful Capital He Built on the Nile

Photographs by courtesy of the Egypt Exploration Society

THE Egypt Exploration Society of England and the United States, now in its thirty-ninth year, has taken up the task of the excavation of the capital of the "Heretic King" Amenophis IV, later named Akhnaton. The systematic excavation of the entire city, section by section, will require a number of years, but the recovery of Amarna as a whole is eminently worth while. The site is of dramatic interest.

Tell El-Amarna, 160 miles south of Cairo on the eastern bank of the Nile, is marked by a vast amphitheater of low, sandy hills worn by water-courses, by a narrow strip of cultivation along the river, by heaps of bricks, fragments of stone, broken walls running in every direction, and finally by one long street among the ruins cleared by the *Deutsche Orient-Gesellschaft.* The city was built on a regular plan, having many cross streets and at least two long main streets of handsome buildings with fine sculptures, and gardens filled with trees and plants of every kind. It was divided into two separate quarters by a valley, now packed with sand and gravel. Here excavation is slow on account of solid debris between house-walls due to alluviation and rubbish from upper buildings. An inscription in the tomb-chapel of May, a noble of the court praises "Akhetaten, the Mighty City of the Horizon of Aton, great in loveliness, mistress of pleasant ceremonies, rich in possessions, the offering of the sun being in the midst: at the sight of her beauty there is rejoicing."

The history and remains of the place are equally singular. From a mere dependency of Hermopolis with no life of its own, it became the seat of imperial administration, for Akhnaton, Pharaoh from 1375 to 1358 B.C., repudiated the Amen-Priesthood, abandoned Thebes, and founded here his glorious new capital "Like Aton in heaven forever and ever." Aton was the "Lord of Peace" who could not tolerate battle and strife. Akhnaton was so opposed to war that he persistently refused to offer armed resistance to the subsequent revolts in his Asiatic dominions. The Egyptiau government became chaotic. An empire gained by 200 years of conquest was scattered and lost in less than twenty years; and with its fall the king died. Upon the death of Akhnaton the religious revolution ended. The court returned to Thebes and the wonder city of Pharaoh's dream was once more a desolate place. Dr. Hogarth writes: "Its greatness had lasted but a moment, and everything important found on the site was made, or at least brought there during that moment. Its period is one of exceptional interest to historians and archaeologists, falling as it does just after the zenith of the imperial eighteenth dynasty, which extended Egyptian dominion more widely over the Near East than any before or after. It was a time of much splendor and great art, to whose inspiration influences of practically all the lands then civilized contributed. Relations with other Mediterranean peoples—for example, the Cretans in their "late Minoan" age—and with Western Asia from Mesopotamia to Asia Minor, were frequent and close. Egypt was for the moment the leading state in the world. Not only the Kings of Knossos, but of Hittite Cappadocia, of Assyria, of the Mitannian State in northern Mesopotamia, and of the Kassite dynasty in Babylonia, courted it and were wary of provoking its wrath. The evidence of these wide relations which the soil of Amarna has yielded up already is the most interesting that, perhaps, has come from any ancient site."

In 1887 the attention of scientists was first directed to the forgotten capital. Natives, pulling down a portion of the palace wall for building material, came upon a store-room filled with bricks of very fine grain, each covered with cuneiform writing. The tablets were hastily heaped in baskets, fastened to the backs of donkeys, and a few days later the dealers in Luxsor and Cairo had on sale the diplomatic correspondence of Amenophis III and Amenophis IV (Akhnaton) with the Babylonian and Syrian dynasts. This find of documents of absorbing historical interest led Professor Petrie to commence excavation of the actual buildings. In 1891 he cleared a group of town houses, finding more cuneiform tablets, the great temple and the king's palace. Like all the residential buildings of the period the palace was an airy and light structure made of brick. The walls, ceilings and floors were covered with beautiful paintings; pillars inlaid with colored glass and stones supported the light roof. A. E. P. Weigall, Inspector of Antiquities in Upper Egypt describes a portion of the designs

painted on the palace pavement: "A young calf frisking in the sunlight, gallops through a field of red poppies; wild geese rise from the marshes and beat their way through reeds disturbing the butterflies: amidst the lotus blossoms resting upon the rippling water the sinuous fish are seen represented in the ponds. These are but fragments of the paintings which once delighted the eyes of Pharaoh." These paintings, among the most valuable monuments in the realistic art of the eighteenth dynasty, were wantonly destroyed by a discharged workman in 1912 who broke into the government shed and reduced the entire pavement to broken fragments and heaps of colored dust. Such misfortune emphasizes the need for excavation and scientific record of a site remote and difficult for the government to protect.

From 1907 the *Deutsche Orient-Gesellschaft* held the site and in 1911 commenced clearance of the city building by building. The German work ended in 1914 with the clearance of the long *Oberpriester-Strasse* which developed into an Egyptian Pompeii of noble villas. Nowhere else in Egypt is there such an opportunity for studying the dwellings of the ancients. Dr. James H. Breasted writes for this article on account of his visit to Tell El-Amarna: "In the light of many years of study devoted to its monuments, and especially in view of an unusually interesting visit to the place which I made only last season, it is a great pleasure to express my conviction of the value of excavations and researches carried on at this remarkable site. To the average traveler the place seems to offer very little of interest; indeed, the tourist steamers on the Nile almost never stop there. On disembarking, the modern traveler rides through the palm groves, and issuing from the cultivation enters what seems to be only a wilderness of the dreariest mounds of disintegrated sun-dried brick extending for miles across the desert; but where these mounds now stretch away under the blazing Egyptian sunshine once arose a beautiful city, the earliest home of monotheism. The Pharaoh Ikhnaton (Akhnaton), to whom the place owed its origin, was a religious and artistic genius, born like most such extraordinary personalities many centuries too soon. His people and his time could not follow him or appreciate the value of his extraordinary vision, and his whole movement toward the worship of a sole God and toward purer truth and realism in art was swept away.

THE LANDING AT EL-AMARNA

AKHNATON, PHARAOH FROM 1375-1358 B. C.

QUEEN NEFERTITI AFTER CHIEF SCULPTOR THUTMOSE

"Today as you walk across the desolate ruins you may trace the streets of the town and the walls of the houses, rising sometimes almost to the level of the ceiling of the ground floor rooms, and displaying here and there the bright colors of the paintings with which they were once adorned. Here was the king's palace. Here were the temples of the sole God. Grouped about these were the villas and the gardens of the powerful leaders whom the revolutionary Pharaoh had been able to rally to his cause. The investigation of these remains is only in its beginnings.

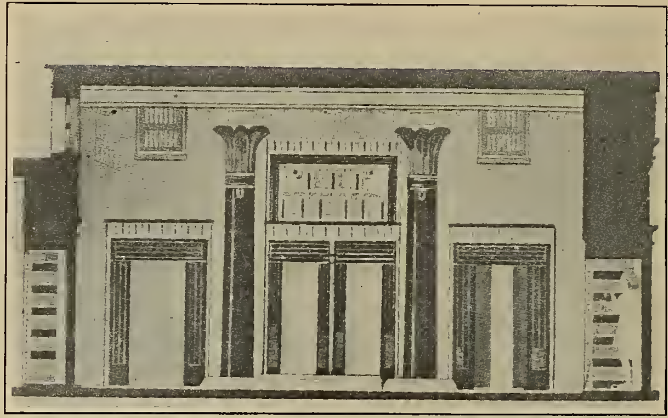
"When I visited the place last season, even the limited extent of the initial excavations already revealed a scene of fascinating interest. I wandered from house to house, passing through the porter's lodge, and sometimes a small vestibule. Behind these one usually found a stately transverse reception or social hall with a raised section of floor at one end fitted with drainage and evidently intended for the wine jars, thickly hung with flowers and garlands, and constantly sprinkled with water, just as we so often see them in the paintings of Egyptian feasts in the towns at Thebes. Behind all this were sleeping rooms, sometimes with a bath, and with hygienically arranged toilet conveniences. Connected with the kitchen might be circular granaries, store-houses and magazines, while behind all was the garden with the stumps of the vanished trees still in posi-

tion, and the well from which the garden was watered still accessible by means of a spiral stairway leading down to the water. The treasures which such houses may still contain have been surprisingly demonstrated by the marvelous sculptures discovered in the course of the German excavations—especially the treasures of portraiture found in the house of the royal sculptor Thutmose, with the studio of the royal sculptor himself attached to his dwelling, and adjoining it a large court surrounded by the booths and alcoves in which his pupils and apprentices carried on their work and their studies.

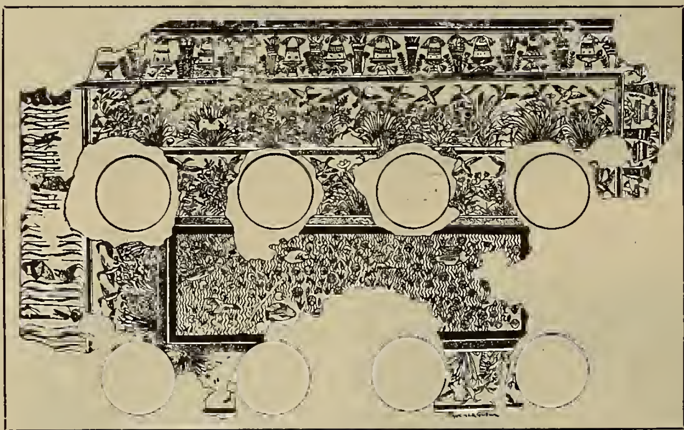
"Never in the whole course of its work in Egypt has the Egypt Exploration Society taken up a site of such extraordinary interest and of such great promise. The work ought to receive wide support from American subscribers, and the fact that the antiquities taken out by the Society are divided pro-rata among the contributing communities in America and Europe offers every possible inducement to Americans who are interested in such work."

An account of the discoveries of the past winter received at Tremont Temple, the American headquarters of the Egypt Exploration Society is surprising and important in scientific results.

Professor T. Eric Peet, Director of the Expedition, sends the account by way of London. The section excavated adjoins the "Oberpriester-Strasse" and was supposed by the Germans to be a cemetery. It proved an ancient village, the dwelling place of the necropolis guards. The village was surrounded by a thick wall having a rather narrow door as entrance to the enclosure. Almost the first stroke of the pick showed that the white ants which had so ravaged wood work in the villas of "Street of the High Priest" had barely touched this area. Rafters and roofing, though fallen in, were preserved almost intact, enabling us to make an advance on the German work in the way of reconstruction. The typical house stands in a spacious enclosure. It is built of mud-brick, and its rooms are roofed with mud and reeds, supported where necessary by columns of wood set on stone bases. In the center of the house was the central hall, whose walls standing higher than those of the surrounding rooms enabled the room to be lighted by a kind of clerestory. In this hall is always found a flat stone tank, draining off into a vase of pottery or stone. Opening into the central hall are two long rooms on the north and west, each of which seems to have had a broad low window in its outer wall which turned the room into a half open loggia. East or south of the central hall is usually a staircase, half of brick and half of wood leading up to the roof. Other apartments include women's quarters and men's quarters, and a bath room containing a stone bath similar to but not to be confused with the tank in the central hall. In the store-rooms remains of the wine and oil jars are still to be found, often marked in ink with the name and quality of their contents.



THE "DEEP HALL" IN THE HOUSE OF GENERAL RA'-MOSE
After a provisionally colored reconstruction. Scale, 1:55



THE DECORATED PAVEMENT OF THE PALACE OF AKHNATON, WHICH WAS DESTROYED IN 1912

SECTION OF PAINTING FROM THE PALACE PAVEMENT

One householder certainly had things more valuable to conceal for he had built a small bricked pit under the brick floor of his central hall. At the time when the town came to be deserted he had taken up the bricks of his floor, broken up the securely plastered stone lid of the pit and removed his treasure, evidently in considerable haste, for he dropped a scarab of lapis lazuli with gold setting on the floor beside the pit. One kitchen was found in perfect order, with oven, tray for baking bread, basket for cooling, vase for water, dough-mixing place, fireplace with poker, unused fuel and the cooking pot. Similarly two rooms have looms in them of which considerable portions remain. Very interesting museum material of a type which is rare was found. Among the implements of labor are sieves, basket-work, wooden tools, portions of looms, spindle whorls, ropes, etc.

The garden contains a great wall, granaries, stables, a cooking place with pottery ovens, a summer-house, and remains of trees. Everywhere are traces of the gaiety and brightness which seem to have characterized the worship of the Sun's Disk and its devotees. Every day brought to light fragments of charming blue-glaze finger-rings, amulets and daintily colored tiles. From the town came several interesting small works of art, sculptor's trial pieces, fine perfect vases of the beautiful variegated glass of the XVIIIth Dynasty and two silver bowls; Mycenean pottery, and a tablet written in Assyrian.

The dated objects are so far of Tutankhamon, which becomes of special interest in connection with the discovery of a series of shrines. On the hill-slope east of the village re-

mains of an entirely new type came quickly to light. A small chamber, perhaps roofed only in part or not at all, ends in a raised dais, behind which is a cavetto cornice only about a foot from the pavement of the niche. The whole structure was whitewashed up to a certain height, and above this were decorations of painted plaster. In the center niche is a small brick pedestal, which presumably held a cult object. A find in another shrine may bear on this. Side by side at the foot of the dais were found an inscribed wooden pedestal, and a wooden disk of the sun which had undoubtedly been mounted on this pedestal by means of a dowel and two pegs. In one of the shrines were two steles. One is a fine funerary stele of Ptaymay who is called "The Approved of Aton." On the front is a scene showing Shed and Isis and prayers to these. A neighboring shrine has prayers to Amon. A small stele of Taurt from the town site and amulets of Bes also mark the intrusion of the old gods and indicate readiness to break with the cult of Aton. These point to the reign of Tutankhamon, who changed his name from Tutankhaten after the death of Akhnaton; four of his scarabs are known reading Tutankhamon, but having the gold-disk of the Aton inserted in the back, a concession to worship of the Sun-Disk in former days.

In connection with the shrines found by Professor Petrie, hope of discovery of the royal shrines is renewed. Weigall, when Inspector of Antiquities, wrote: "It would seem that there were shrines dedicated to Akhnaton's ancestors in the City of the Horizon, each of which had its steward and its officers, and it is probable that Akhnaton arranged that a memorial shrine of the same kind should be erected for himself against his death, for we read in the "Rock-Tombs of El-Amarna" of a personage who was "second-Priest" of the king. There is also a representation of Akhnaton offering to Aton in the House of Thotmes IV (his grandfather) in the City of the Horizon. It was Akhnaton's desire to show in this manner the continuity of his descent from the Pharaohs of old and to demonstrate his real claim to the title "Son of the Sun," which had been held by the sovereign of Egypt ever since the Vth Dynasty. It was in this manner that he claimed descent from Ra, who was to him the same with Aton. Even as the great religious teachers of the Hebrews made careful note of their genealogies in order to prove themselves descended from Adam and hence in a measure from God, so Akhnaton thus demonstrated the continuity of his line in order to show his real right to the titles "Child of Aton" and "Son of the Sun."

THE GRASPING INSTINCTS OF YOUNG ANIMALS IN THE LIGHT OF EVOLUTION

In newly-born mammals there is frequently found a remarkable grasping instinct. Everyone has noticed this in young babies, who exhibit a really marvelous power of "holding fast" to a finger or a stick. Writing in *Kosmos* (Stuttgart) for April, 1921, Mr. H. Radestock points out that this represents the survival of a highly useful atavistic power. This faculty is confined chiefly to those animals, including man and great apes, which are known as breast nurslings, and in a somewhat less degree to the pouch nurslings, which include kangaroos and marsupial rats. This is because the instinct referred to is not especially useful to those animals which nurse their young in a recumbent position such as dogs, cats, rabbits, etc., or to those where the infant is able to take its food standing—like calves, colts, fawns, young elephants, etc.

In some recent investigations upon this subject the well-known naturalist, Professor Doflein, divides the first-mentioned mammals into two classes, those in which the new-born offspring cling to the fur of the mother by means of hook-like incisors, as do all the bats, and those which cling to the mother's breast with the hands and feet, like the young of the man-like apes and of man himself. It has long been a matter of remark, in fact, that among certain African tribes the mothers carry their young infants while walking or while working in a manner quite similar to that employed by the great apes. It is true that they add to the security of the child by a primitive method of fastening it to the body, but it is quite noticeable that the little creature clings to its mother's torso by means of its arms and feet with a really wonderful degree of firmness and endurance. Apropos of this we may mention Professor Mitchell's well-known experiments with regard to the grasping power of young infants. Most of them are capable of hanging suspended from a rod when gripping it with both hands for a considerable length of time, while a few young Hercules are capable of hanging by one hand. And since at the same time they make instinctive motions with their legs, they look uncommonly like young gymnasts.

It has hitherto been quite a puzzle as to why children so quickly lose this power. The answer to the riddle is given through a very simple experiment described by Dr. E. Moro in the Munich *Medical Weekly*. If a young infant be laid upon a mattress and the latter then be slapped smartly with both hands one on each side of the child the latter's arms and legs will at once fly apart in symmetrical curves and immediately afterward, approach each other with an energetic contraction. This is an automatic grasping movement produced by fright; its object being naturally the clasping and clinging to of the mother's body. It must be regarded, therefore, as a primordial flight reflex, an instinctive measure of protection, which in the prehistoric days of our race enabled the mother at once to take flight with her baby hanging on tight to her body, and thus not impeding her through the necessity of carrying it in her arms. After the infant is weaned this instinct is no longer necessary and consequently becomes atrophied. Observation has shown that the convulsive contraction of the arms and legs in young children persists more than three months. This similarity between the instincts in young children and in the offspring of the higher apes is another proof that both these families of primates sprang originally from a common stock.

GENERATORS FOR WIRELESS TELEGRAPHY

Karl Schmidt, a German radio engineer, reviews in this paper some German developments in the radio field during the war. Designers of medium-frequency and high-frequency generators will find in his paper details, drawings and photographs never before published. The largest part of the paper deals with different types of generators used for the operation of quenched-spark sending stations, *i.e.*, machines producing up to 600 cycles per second. The author describes several solid-steel rotor, unipolar machines and gives their characteristics. There has been a large demand for medium-frequency machines of from 0.05 kw. up to 300 kw. output, which has resulted in highly developed standard types. During the war a large number of these machines, rated at about 350 watts, 600 cycles, and simultaneously at 200 watts, 500 volts direct current, operating at 4,500 r.p.m. and weighing only about 17 pounds, have been used on airplanes.

Considerable attention is given a new type of generator developed by the author during the war which found widest use in the German army and navy. It is a type with all windings stationary and a laminated toothed rotor. The author claims for his machine the smallest weight and highest efficiency ever reached for such generators; for example, 11 lb. for 500-watt alternating current plus 250-watt direct-current type, or 82 per cent efficiency for a 2-kw. type. A very compact, portable, gasoline-driven 1.5-kw. alternating-current plus 1.0-kw. direct-current type is also described.

Dealing with high-frequency machines the author does not consider it as reliable to go beyond 3,000 r.p.m. or 450 ft. peripheral speed per second. The multiplying of frequency in stationary transformers according to Jolly-Arco and Goldschmidt is touched upon, assuming eightfold and threefold, respectively, as safe limits. Characteristic curves are given of a 7,000-cycle machine in actual operation.—*Elektrotechnische Zeitschrift*, March 17 and 24, 1920. Also *Electrical World*, June 11, 1921.

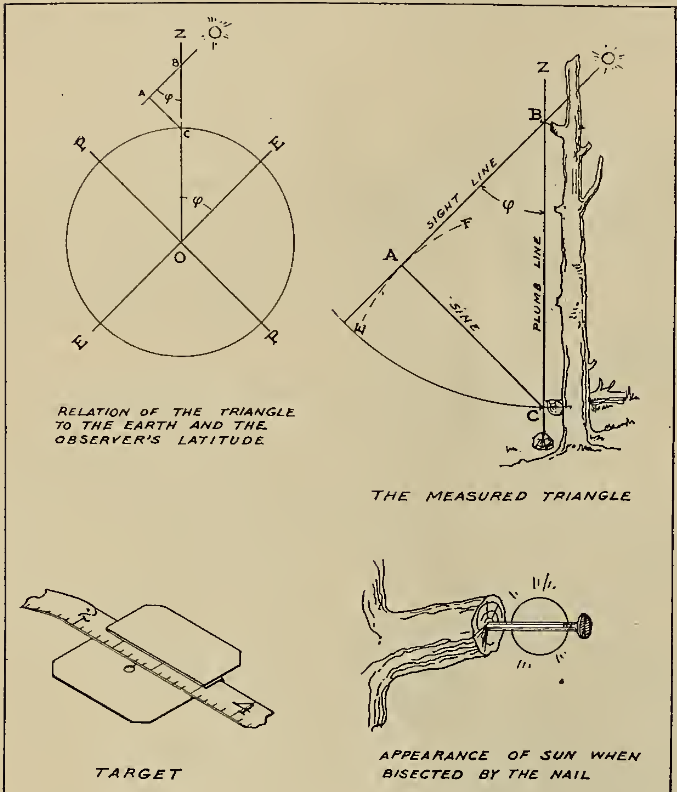
Latitude Without Instruments*

How the Man in the Woods Can Make an Excellent Determination

By Russell W. Porter

"NOT within a mile of the truth" usually means that something or other lies very far from the mark. Locating ourselves within a mile of the truth on this immense globe of ours would, however, be considered a pretty close approximation. To do it with only a string, this approximation would seem to be a remarkably close one.

Two winters ago a good friend—William Brooks Cabot of Boston—well known for his exploratory work in Labrador, suggested that latitude could be determined in the field without an instrument of precision. He deplored even the addition of a pocket sextant and horizon to a camper's pack where dead weights must be shaved to a minimum; that the tools irreducible to the explorer—a knife, hatchet and fishline—together with nature's available materials, would suffice to obtain latitude within a mile. He had not put the theory into practice, however.



LATITUDE WITHOUT INSTRUMENTS

And the writer, doubting that any such accuracy could be reached, put the method to the test. He was greatly surprised, after several false starts, and hitting luckily at last on a novel expedient, to find that latitude could be obtained with a steel tape to well within a statute mile; time (and hence longitude) correspondingly.

The problem resolves itself into the measurement of a vertical angle. In Todd's "New Astronomy," page 82, is described a simple way of finding one's latitude. It obtains the zenith distance by allowing a beam of sunlight to fall on a graduated arc oriented in the observer's meridian. It will probably give one's latitude to the nearest degree.

If now we take the simple case of the sun on the equator at noon, and suspend a weighted line BC from any convenient support, and from its lower end stretch another line AC to our eye when it sees the sun and the point B in line, we have formed a right angle triangle in which the angle ABC will be our latitude. This statement is made clear in the smaller diagram, where an observer at A finds that the angle between his zenith and the equator (in this case a very distant object lying in the plane of our equator) will always be his latitude.

Now in this triangle ABC the hypothenuse BC is readily and accurately determined. The plumb line may be suspended from the limb of a tree or from a nail driven into the top of a porch post, or on the corner of a house. A good working length is about ten feet. Since the angle we desire is angle ABC, if we can measure the side AC then the sine of this angle is at once found and the angle may be taken directly from a table of sines.

It now remains to work out a convenient means of measuring this sine, and the writer has found that the following procedure gives the most satisfactory results. While a fishline or cord can be used, since the ratio only of AC to BC is required, yet more accuracy is attained with a small pocket steel tape whose feet are divided into tenths and these again into tenths. As these last divisions may be estimated to tenths, we obtain readings to one thousandth of a foot.

The point C at the lower end of our plumb line is next fixed in a secure manner.

I have found it practical to bring the end of a sapling or small log up to the base of the tree when in the wilds, and to drive a nail into the butt opposite to some whole division on the tape. This end of the plumb line is of course already provided for the nail if we use a house corner or porch post.

The other end of the sine line, at A, can be found by the use of a screen or target in which a small hole has been bored, and the target capable of being slid along the tape to any desired position. A sketch of this is shown in the figure. For use with the sun a piece of colored glass must cover the pin hole to protect the eye, but with the stars at night an ordinary visiting card suffices.

If now the buckle of the tape is hooked over the nail at C and the tape drawn taut over the head of the observer as is shown in the second degree a position will be found where the nail at the upper end of the plumb line is seen to just bisect the sun's disc. The appearance then will be shown as in the figure, and the head must be moved up and down and the target shifted until the sun is bisected with the *minimum length of tape*. That is, a position will be found as the target sweeps through the arc EF, where the sun seems to rise toward the nail, remains stationary a moment and then falls away. It is at this middle position that the tape is at approximately right angles to the sight line AB, and the length of the sine may then be read off on the tape just opposite the pin hole.

With a little experience this operation of getting the eye, the target, the nail and the sun all in line, becomes an easy one, and if you have been careful in locating these three points of our triangle the observation is finished, and if your plumb line is ten feet, and the sun is on the celestial equator, the angle corresponding to the sine you have measured is your latitude, without further computation.

The sun, however, is on the equator or is "crossing the line" as navigators say, but twice a year—in March and September. Its distance north or south of this position (that shown in the figure) is given for each day in the almanac. It is called the sun's declination. If it is north of the equator—between March and September—this declination must be added to the angle obtained by observation in order to obtain the latitude.

One other small correction is necessary—that caused by re-

*From *Popular Astronomy*, April, 1921, pp. 197-204.

fraction. The sun is never really as high as we see it in the sky, because the light coming from it to the eye is bent down on passing through our atmosphere. This correction for the sun in our latitude never amounts to over two minutes of arc: in summer it is less than one minute. By reference to the figure (1) it will be seen that the angle observed, viz.: ABC is the same as ZBS: that is, we have measured the angle from a point directly overhead down to the sun what is known as the zenith distance. This angle, on account of the refraction, is too small, and therefore this correction is always to be added.

That is all there is to it. The steps are as follows:

1st. Fix two points ten feet apart with the plumb.

2nd. Find the angle between this line and a sight line through the upper point to the sun by measuring its sine.

3rd. To this angle add the correction due to refraction, and apply the sun's declination from the almanac—plus if north and minus if south of the equator.

The result is the latitude.

The above description has been written especially for the

MEASURING THE DIAGONAL

young student who would know something of practical astronomy, but who fears it is beyond him; fears that there is something very mysterious about it, involving higher mathematics, years of application and the use of delicate and expensive instruments beyond his reach. The purpose of this article is fulfilled if it stimulates some one to put his knowledge of plane geometry to practical use, and leads him to further inquiry.

To the reconnaissance surveyor, and to the astronomer it may be of interest to know that this method of determining latitude and time is susceptible of considerable refinement. For instance, the triangle may be referred to the centers of the two nails at the ends of the plumb line, and the center of the pin hole of the target. The buckle at the end of the tape may be deformed so that the tape divisions will read from the nail centers. The diameter of the pin hole cannot be much less than 2 mm. if stars are used. With the sun somewhat less than a millimeter hole is about right. The bisection of the sun's disc seems to be reliable to less than a minute of arc. An error of one thousandth of a foot in the sine for a summer meridian altitude in our latitude affects the angle sought about half a minute of arc. The following circummeridian zenith distances on the sun, using a theodolite to check the angles are submitted:

LATITUDE FROM CIRCUMMERIDIAN ALTITUDES OF THE SUN AS DETERMINED BY TAPE LINE

Springfield, Vermont, August 8, 1920

Watch 75th Mer. Time			Tape Reading	Zenith Distance		Z.D.Red. to Meridian		Latitude		Res.
h	m	s	mm	°	′	°	′	°	′	′
11	41	30	1457.5	27	17.4	27	12.8	+43	19.8	—1.3
	47	20	1453.0		11.9		11.1		18.1	+0.4
	52	10	1452.5		11.3		11.3		18.3	+0.2
	56	50	1453.0		11.9		10.2		17.2	+1.3
0	2	30	1459.0		19.2		12.0		19.0	—0.5
	8	0	1464.5		25.9		11.4		18.4	+0.1
Length of plumb line, 3179.0 mm.							mean	43°	18.5	
Latitude by theodolite,								43	18.3	

The first two columns represent the observations. The third and fourth give the steps in reducing these observations to the meridian. In the fifth column the corrected sun's declination is applied, giving six independent determinations of latitude. The last column shows the amounts by which each determination departs from the mean derived latitude.

Finally, in a triangle the size of the one described a considerable departure from the right angle at A may be allowed before it disturbs the angle sought by as much as a minute of arc.

The writer attempted a further improvement by placing a totally reflecting prism at A so that the observer could look down the sine at a convenient angle against a dark background (case of the sun). He found that any improvement in convenience of posture was offset by the vibration and shifting of the objects viewed through the prism due to its unstable mounting. Even the pentagon prism proved of little help.

GOFIO—A DELICACY FROM THE CANARY ISLANDS

ONE of the curious relics of a very ancient past in the Canary Islands is the popular delicacy known as *gofio*. This consists of wheat which has been first roasted and then ground into flour or meal. It is sometimes eaten in the form of the flour as soon as it comes from the mill, but this requires some skill to prevent its choking the air passages with dust. A common method of preparing it, however, is to knead the dry powder into a cake by adding water and a pinch of salt. The dough thus formed is then pressed into a bag of peculiar form made from the skin of a young goat in order to shape it, after which it can be sliced and eaten like bread. Sometimes the flour is merely added to other foods such as soup, milk, coffee, beer, wine, chocolate, oil, etc., to increase their nutritive qualities. The natives of Teneriffe also have a habit of dipping oranges, bananas, figs, and other juicy fruit in gofio before eating them. That this substance is highly nutritious is shown by the following analysis which we find in an article upon the subject by Dr. L. Lindinger in *Kosmos* (Stuttgart) for March, 1921.

Albuminous matter, 104 gr.; fatty substances, 17 gr.; carbohydrates, 716 gr.; yield in calories, 3,483.30. These figures apply to one kilogram of gofio.

Dr. Lindinger describes the method of preparing gofio as follows: After the wheat has been sorted to free it from impurities, it is spread upon a flat earthen dish on a stove and stirred constantly with a wooden stick, one end of which has been wrapped in cloth, until it has been roasted to a pale brown color. This simple process in which the starch is transformed into easily soluble substances, probably into sugar and dextrine, is all that is required, but in Europe it is more common to use a regular roasting machine like that employed for coffee. After being roasted the wheat is ground in any convenient manner, even in a strong and well made coffee mill.

The same process is sometimes applied to other grains such as barley, rye, and maize and to peas, and in times of scarcity even to fern roots, and to certain seeds and fruits.

Does the Earth Emit Ultra X-Rays?

A New Theory of Radioactivity Suggested by the Swiss Scientist, Jean Perrin

THE essential phenomenon in radioactivity consists in the continual emission of radiations by preparations containing certain remarkable simple bodies, which have been termed radioactive bodies. Radioactivity is never produced in atoms which remain intact; it denotes the disintegration and transmutation of certain ones among them. It is during this disintegration that the atoms emit rays. Thus each atom of radium remains strictly intact until the instant when it is *abruptly* dislocated yielding an atom of helium and an atom of radium emanation.

This is generally explained by assuming that by reason of chances whose average alone can be foreseen, every radioactive atom (or more exactly the nucleus of this atom) is capable of suddenly exploding and dissociating itself into constituents which have been hitherto masked (*i.e.*, into helium and radium emanations in the case of radium), with the liberation of an enormous quantity of internal energy. It is an *explosive atom*, the profound underlying cause which releases the explosion being supposed to be the accidental realization of certain conditions in the interior of the positive nucleus of the atom.

Struck by the analogy between the phenomenon of radioactivity, in which each emission of rays marks the death of an atom, and organic fluorescences, in which each emission marks the death of a molecule, the eminent Swiss scientist, M. Jean Perrin, was led to extend to the field of radioactivity his theory of chemical reactions, namely: that the disintegration of radioactive atoms is produced through the direct influence of a certain radiation. This is an extremely bold theory since it is exactly opposite to the one usually accepted. However, thus far, no fact is known capable of contradicting it.

To begin with, if radioactivity is produced by a certain radiation of external origin, it is necessary to assume, since radioactivity is not affected by variations in temperature, that so far as concerns the intensity of this active radiation we must regard as negligible the intensity (for the same frequency), of the internal radiation of enclosed spaces raised to as high a temperature as we are able to attain.

"It is evident that we cannot be here concerned either with the infra-red rays, those of visible light, or with ordinary ultra-violet rays, all of which manifest their existence otherwise than by the radioactivity excited (*e.g.*, by clouding photographic plates). Furthermore, since no screen and no enclosure either suppresses or appreciably reduces radioactivity, it must be assumed that all walls (and especially the walls of our laboratories) are highly transparent with respect to active radiation. This eliminates not only all the ultra-violet rays as far as the X-rays but also the X-rays themselves and even the γ rays—in other words all known rays of light are eliminated."

"But when we approach by increasing frequencies the limits of this known light we are well aware that the power of penetration increases. X-rays long ago excited our surprise by showing themselves capable of traversing sheets of metal, and γ rays of a frequency altogether not much greater, are capable of traversing, without being much diminished, blocks of lead from 10 to 20 cm. in thickness. It is not unreasonable to suppose that beyond these γ rays there may exist rays of light much more penetrating, which it is possible to conceive of as producing the phenomena of radioactivity."

These rays cannot proceed from the sun by reason of the fact that measurements made by Madame Curie have proved that radioactivity does not vary during the night, but "it is quite possible that this active radiation issues from beneath our very feet, from the hardened center of the planet itself."

ULTRA X-RAYS

M. Perrin proves in fact that it is perfectly reasonable and logical to assume that the earth is constantly emitting *ultra-X-rays*, which are much more penetrating than either X-rays or γ rays, so much so, in fact, as to be able to traverse a thick layer of rocks—and that *these ultra X-rays produce the various forms of radioactivity observed by us.* It is needless to remark upon the fact that the internal radiation of our furnaces could in no way augment the intensity of these rays and, consequently, could exert no effect upon the rates of disintegration.

Under the action of these ultra X-rays, atoms might be capable of undergoing changes quite comparable to the ionization which they undergo under the influence of the X-rays; but by reason of the much higher frequency the ionization would be much more intensive if it were produced and might even have an effect upon the positive nucleus of the atom, in such a manner as to occasion a real transmutation.

The calculations made by M. Perrin have led him to attribute to the ultra X-rays a frequency of the order of 3×10^{21}, which corresponds to a wave length $\lambda = 10^{-11}$ cm., only one five-millionth as long as that of yellow light. This gives us a satisfactory result: Radiations which are as penetrating compared to X-rays as are the latter compared to visible light, must indeed have an exceedingly high penetrative power—a power quite sufficient, doubtless, to enable them to traverse the crust of the earth where, perhaps, they would run scarcely any risks of being absorbed except by precisely those atoms which they are capable of causing to disintegrate.

An advantage of this new theory over that of the explosive atom lies in the very fact that it suggests the possibility of making experiments and verifications; thus, the idea presents itself that a radioactive substance may be partially protected against the ultra X-rays by means of a screen which is highly radioactive—a screen which is, indeed, made of the same substance and capable, therefore, of absorbing the same rays; to mention one instance in particular, measurements might be made in radiferous territory.

Another idea which suggests itself is that experiments might be made at various altitudes, since the intensity of the radiation emitted by the earth ought theoretically to decrease with the height, following exactly the same law as that which governs the strength of gravity. In this case the average life of a radioactive element ought to increase with the altitude in inverse ratio to the strength of gravity. When we remember the great heights which it is now possible to attain by means of an airship it will be readily seen that it would be possible to make a critical experiment so soon as we have become positively certain of the thousandth part in the measurements of radioactivity. It already seems probable that we are not very far from this goal.

This new theory does away with the peculiar character which has been believed to be connected with atomic disintegrations, which are to all appearance very strongly exothermic, and the molecular dissociations, which are endothermic. As a matter of fact the breaking up of radium, far from liberating energy, as supposed, absorbs an enormous quantity of it, according to Perrin's view—but the absorbed energy, none of which is evident to us, is radiated by the earth and does not come from our foci. The energy emitted in the form of α, β or γ rays is not borrowed from the atom at all, but merely forms a portion capable of being utilized by us of the energy borrowed from the ultra X-rays, another portion having arrived to increase the internal energy of the transformed matter.

M. Perrin concludes: "Thus the radioactive atom is not to be considered as being analogous to a magazine of dynamite—*it is not explosivé.* It is, on the contrary, a very stable system which cannot be split up except by a prodigiously difficult *tearing apart.* So that if we accept this view it is necessary to revise all those conclusions wherein the sign of the energy

is supposed to play a part in the radioactive transformations."

This observation enters into the explanation furnished by Langevin of the discrepancies of the atomic weights with respect to the whole numbers which we ought to have, if it be true according to Prout's hypothesis that all atoms are derived from a single element, such as hydrogen for example, in a more or less condensed state. Such differences can be explained by means of one of Einstein's theories, according to which energy possesses mass—or to state the matter more exactly, the mass of an object which either emits or absorbs energy is correspondingly diminished or increased in grams by the quotient w/V^2 of the number w of ergs lost or gained by the square of the velocity of light.

When the energy w is that of an ordinary chemical reaction, this variation of mass is entirely negligible, and we know, in fact, as was discovered by Lavoisier, that the mass is the same before and after the reaction. But in the case of a radioactive transformation the energy w is so great that the variation of the mass ought to become appreciable. For example, the transmutation of radium per atom-gram ought to produce variations of the magnitude of the centigram.

However, as yet no one has paid any attention to the *signs* of the variations. If the radioactive transformation were really explosive in nature, as has hitherto been thought, there should be a loss of mass involved. But if, on the other hand, for the reasons set forth above, this disintegration is *endothermic, i.e.*, accompanied by a gain of energy, then it will be accompanied by an *augmentation of the mass*. Reciprocally, an atomic condensation will be accompanied by a loss of mass. This, indeed, is probably what takes place if we assume it to be a fact that all bodies are formed of hydrogen. We need only to read the list of atomic weights to see that three gram-atoms of hydrogen weigh 3 centigrams more than 1 gram-atom of helium; in the same way 16 gram-atoms of hydrogen weigh 12 centigrams more than a gram-atom of oxygen and so on. This is why Perrin says:

"These numbers are of suitable magnitude and *of the predicted* sign. They are *inexplicable* under the theory of the explosive atom."

In the above paragraphs we have presented a brief but complete digest of Professor Perrin's brilliant article in the Revue du Mois (Paris), for Feb. 10, 1920. While this abstract, for which we are indebted to the Revue Scientifique (Paris) for Feb. 12, 1921 will be sufficient to give the general reader an idea of the boldness of Prof. Perrin's theory and its importance to the new science of radioactivity we are adding for the special benefit of those particularly interested in this new science a detailed translation of a portion of the original article. Our readers are already familiar with the brilliant character of Prof. Perrin's researches upon phosphorescence and fluorescence and with his novel and ingenious theory concerning the laws of chemical reaction. Daring as his concepts are they are based upon years of study and personal research. His article is dedicated, by the way, to J. H. Rosny, the elder, the author of the well-known work of fiction entitled La Force Mysterieuse.—Editor.

NEW THEORY OF RADIOACTIVITY DISINTEGRATION BY TEARING APART

* * * Now that we understand the mechanism by which temperature influences the velocity of reaction, we can readily imagine conditions in which a chemical reaction might remain unaffected by any variations of temperature to which it is within our power to subject it. Thus, the fluorescence excited by sunlight in a solution of uranin is the same at the temperature of melting ice and at that of boiling water, because the quantity of active light, added by the internal radiation to the solar radiation, is entirely negligible within these limits of temperature.

But if radioactivity were produced by a certain wave length of light, as chemical reactions are, it would be necessary in the same way that this light should be of external origin, and that with respect to its intensity we might regard as negligible the intensity, for the same frequency, of the internal radiation within the limits of the highest temperatures which we are able to attain.

It is evident, therefore, that such a form of light could not be visible light, nor infra red, nor ordinary ultra violet rays since these manifest themselves in other ways than by exciting radioactivity. * * * Furthermore, since radioactivity is practically unaffected by screens and by distance the theory requires us to assume that all walls are transparent to the active radiation * * * thus eliminating all known light.

But when we approach by increasing frequency the limits of this known light, we are aware that its power of penetration increases. * * * It is not unreasonable to believe, therefore, that beyond the limits of the γ rays there may be more keenly penetrating forms of light and to assume a possibility that these may produce the phenomenon of radioactivity. As we have seen, experiments have shown these rays cannot proceed from the sun. But another origin is possible, and one which apparently has hitherto occurred to no one:

It may be that the active radiation springs from beneath our feet from the glowing center of our own planet.

THE ULTRA X-RAYS

We shall see that if we assume that the earth continually emits ultra X-rays far more penetrating than either X-rays or γ rays, and that these ultra X-rays produce the various sorts of radioactivity known to us, the conclusions derived from such a theory are entirely logical. * * *

Under the action of these ultra X-rays, atoms may undergo changes comparable to the ionization produced in them by X-rays. But, because of the much higher frequency and of the magnitude of the corresponding quantum hn. the ionization in case it were produced, would be much more profound.

In the first place certain electrons which are already very deeply placed and which the X-rays are incapable of tearing away, might be projected towards the exterior with velocities characteristic of the atom, as in the case of ordinary ionization, thus forming a "spectrum" of β rays like that which Danysz discovered in radium preparations.

However, in the positive *nucleus* of the atom there is no real transmutation, no disintegration. Sooner or later, and assisted if need be by certain radiations, the atom which has become positive will recover the electrons which it lacks and will rearrange itself (with fluorescence) into a neutral stable system, reproducing the primitive atom. (Is this true perhaps in the case of potassium which emits β rays and yet appears not to be transmuted?)

But the nucleus itself would be modified or broken in the case of transmutation. And the ultra X-rays might then be capable, at the expense of enormous labor, of tearing away one or another constituent. This reaction is similar to ionization, but this time positive centers and not electrons alone would be expelled.

* * *

We are obliged to omit here the mathematical equations by which M. Perrin supports his theory. His general conclusion, based upon elaborate calculations, is that the frequency of the exciting ultra X-rays correspond to a wave length which is only the 20-millionth part that of yellow light.—Editor.

* * *

The other radioactivities give us figures representing corresponding magnitudes.

This result is most satisfactory. Radiations of such high frequency as these must be extremely penetrating, enough so doubtless to pass through the crust of the earth, where, perhaps, they are not absorbed except by those very atoms whose disintegration they occasion. At the same time this theory adds 10 more octaves to the diapason of luminous radiation, so that we see

it sweep through about 30 octaves, beginning at the extreme infra red.

PROBABLE VARIATIONS AND RADIOACTIVITIES

Our theory is developing with coherence but, of course, we must demand more than probabilities to convince us. An advantage of the new theory over that of the explosive atom lies in the very fact that it suggests experiment and verification. * * * It is by no means certain, however, that the radiation from the earth always possesses the same intensity at any given spot, and if the central fires are subject, as is probable, to local variations, recalling sun spots, then corresponding variations in radioactivity can be predicted.

THE ENDOTHERMIC NATURE OF RADIOACTIVITY

* * * Far from the disintegration of radium liberating energy it *absorbs* an enormous quantity, but this absorbed energy is radiated by the earth and not by our foci. The energy emitted in the form of α, β or γ rays * * * is merely borrowed from the ultra X-rays. Hence the radioactive atom is *not explosive*, but, on the contrary, a very stable system which cannot be disintegrated except by a prodigious tearing effort; hence we must revise all those previous conclusions in which the sign of the energy of radioactive transformations is supposed to play a part.

If, contrary to what we have previously supposed, the radioactive disintegration is *endothermic* on a colossal scale, then the inverse reaction consisting for example in the formation of radium from radon and helium would be exothermic on an equally huge scale, and would approximately resemble in magnitude the transformation of ozone into oxygen. And in the same way that this destruction of the ozone, though exothermic, requires the action of suitable radiations and consequently, practically never occurs within opaque boundaries which are too cold. In the same way the association of radon and helium to form radium may require either a suitable external radiation or, possibly, a minimum temperature which it is probably beyond us to attain; (furthermore, the return may be effected by stages, as in the case of phosphorescence). One can already guess and we shall soon indicate what this leads up to.

PROTO-ATOMS, UNITS OF MATTER

Radioactive transformations have revealed to us that there are some atoms, at least, which are very complex, and which do not differ from ordinary molecules except by the magnitude of their energy of formation. Reciprocally, we have discovered, and not without some stupefaction, that at a temperature su ficiently low, *i.e.*, with a very poor internal radiation, *molecules may exhibit certain properties of atoms.* Thus, below 30 deg. cent. absolute diatomic hydrogen assumes the specific heat common to all of the monatomic gases, such as argon (Eucken).

From those elements which really deserve the name of atoms and which we may term *proto-atoms;* there are built up all the atoms and all the molecules, and these proto-atoms, which resist the most powerful efforts of light, include only a small number of kinds. The negative electron, a universal constituent of all atoms, is one of these proto-atoms. The positive nucleus of hydrogen is another one. Perhaps this is true also in the case of the positive nucleus of helium which still remains after more than 20 radioactive disintegrations. And with respect to helium it is startling to find that in the list of atomic weights of non-radioactive bodies, 10 of the differences are equal to 4, which is the atomic weight of helium.

Possibly even the nucleus of helium is complex. Rutherford * * * regards it as formed by 4 hydrogen nuclei and 2 electrons * * *.

The nucleus of hydrogen and the electron (the latter having a mass only about one two-thousandth part as great), would then be the only proto-atom, and here we come across an ancient hypothesis, known under the name of Prout's Law, to the effect that in the last analysis all simple bodies are merely more or less condensed forms of hydrogen. * * *

If it be a fact that every atom is made up of nuclei of hydrogen and electrons of relativity negligible weight, then it would seem that all atomic weights should be multiples of that of hydrogen—and as a matter of fact this is approximately true in the case of a large number of elements, though there are some indubitable exceptions.

I will not here state the reasons which lead us today to believe that in these exceptional cases (magnesium, silicon, chlorine, etc.) we are dealing not with a single, simple body, but with a mixture of simple bodies having different atomic weights and yet possessing properties so similar that it is extremely hard to separate them. In this concept, which we owe to Soddy, and which appears continually more probable, natural chlorine, for example, is held to be a mixture of *isotopic* chlorines, which are practically inseparable and which verify Prout's Law separately. But I should like to emphasize just here another thing not yet pointed out but which lends support to my theory concerning radioactivity.

EXPLANATION OF DISCREPANCIES WITH PROUT'S LAW

This section was sufficiently covered in the preliminary abstract to which the reader is referred.—EDITOR.

THE INFLUENCE OF COSMIC CONDITIONS

The theory set forth in a recent article appears to involve consequences which are of interest from the viewpoint of astronomical physics and cosmogomy.

We have already observed that radioactivity ought logically to change with altitude. Instead of confining ourselves to those variations of latitude which are accessible in practice, let us suppose that the radioactive substance grows more and more remote to infinity. In this case the intensity of the ultra X-rays which it receives from the earth would incessantly diminish in inverse ratio to the square of the distance from the center of the earth. When the radioactive body passes the plane of the orbit of the moon, the ultra X-rays emanating from the earth will have become so feeble that if they alone be taken into consideration, the average life of the atom of radon, instead of being a period of six days would have been lengthened to one of sixty years. As a matter of fact it then becomes necessary to take into account the ultra X-radiation which undoubtedly emanates from the sun and which, having undergone scarcely any diminution because of the enormous distance of this star, may perhaps then be the predominant factor. Let us assume, according to what seems to be the fact, that upon the earth the ultra X-radiation coming from the sun is less than one-hundredth part of that proceeding from the earth; then at the distance in question the average life of radon will be more than two years in length. If we now suppose that our radioactive body continues to grow more remote from the solar system, the probability of its disintegration will constantly diminish, so that in the intersiderial spaces it will become practically eternal, since taking into consideration the vastness of interstellar distances its life will be at least a million times as great as upon the earth. Like other reactions radioactivity will be benumbed amid the cosmic dust which, swung by the stars, as we see in the tails of comets, becomes inert and cool as it passes from one stellar system to another: yet, meanwhile, it bears within itself the possibility of being reawakened when it reaches some far distant world.

THE AURORA BOREALIS—CORRECTION

PROFESSOR STÖRMER'S article on the above subject which appeared in our July issue, had to go to press before the author's proofs were received. He notes the following correction: On page 12, first column and seventeenth line from the bottom of the page the distance "fifteen million kilometers" should, of course, read *a hundred and fifty million kilometers.*—EDITOR.

The Deadly X-Ray and the Innocent Bystander

Should Insulating Sheets of Lead Be Required by Law for Rooms Employing X-Ray Apparatus

Both in this country and abroad the public has recently been deeply shocked by the cruel deaths of some of our most brilliant pioneers in the study of the X-ray. One of the most recent of these was the French scientist, Leray, and apropos of his dreadful death there has been much discussion in the French press as to whether such premature perishing of radiologists is inevitable or due to carelessness bred by familiarity. Dr. G. Contremoulins, one of the most eminent radiologists in France, and head of the principal laboratory of radiography connected with French hospitals, has made the disturbing declaration that because of the greater penetrating power of the radiations now in use not only operators and assistants are in danger but even employees in adjoining rooms. So grave does he consider this danger that he urges the passage of a law compelling all radiological "stations" to be encased in thick slabs of lead to prevent the rays from passing through the walls after they have acted upon the patients under treatment.

Because of the great importance of the subject we shall here attempt to give an accurate idea of the facts upon which M. Contremoulins bases his fears and of the remedy he proposes.—Editor.

During the last few months Dr. G. Contremoulins, the distinguished French radiologist, who holds his clinics at the Hospital Necker, and who was in charge, during the war, of this branch of the military service, has laid before the French Academy of Sciences certain very interesting communications setting forth in detail experiments made by him with the purpose of demonstrating that the X-rays now in use for medical and other purposes are so much more powerful than those in use in the early days of science as to be dangerous even for the public whose business brings them into the neighborhood of X-ray apparatus, even in adjoining rooms. These communications, which were presented by M. Lippmann, aroused a heated controversy, some of it so acrimonious, indeed that their distinguished author prayed that learned body to appoint a commission to examine into the justice of his claims, remarking very truly that, in a science so new, it is certainly best to be upon the safe side, particularly in view of the number of victims this mysterious force has claimed during the brief quarter of a century or so since they were discovered.

The following paragraphs consist chiefly of excerpts from M. Contremoulins's own writings as published in the Paris press and in the *Comptes Rendus* of the Academy of Sciences. Writing in *Le Démocrati Nouvelle* (Paris) for April 10, 1921, he says:

"Since the discovery of the X-rays in December, 1895, they have been used in many laboratories and medical cabinets as well as more recently in the metallurgical industry and in that of precious stones. But their use is most general in medicine, and all operators are, as a usual thing, exposed to the injurious effect of these radiations since the protective measures furnished them by industrial manufacturers are only too often dangerously ineffective and most deceptively so. Young radiologists especially those born of the war, take no heed of the experience acquired by their elders, being quite convinced that the glasses, gloves and aprons containing lead offer a perfect protection—they even imagine that strictly speaking they might get along without these.

"Like a child which hides behind a wooden door to shield itself from the bullets of a machine gun, our young radiologists believe they are safe when they have donned their gloves and examine their patients behind a sheet of lead glass. But, unfortunately, these enable them only to avoid those superficial skin affections caused by the most absorbable rays of the spectrum.

REGIONS OF DUCTLESS GLANDS

"But they receive alas, those other radiations which are more penetrating, and these slowly produce lesions of all the ductless glands in the body, whose internal secretions we now know to be of such vital importance in the bodily economy.

"It is to such lesions that the lamentable death of Leray, Infroy, and so many other students have been due.

"But is it only the operators themselves, we may ask, who are subjected to these attacks from the radiations received in the course of their researches?

"Alas, no! Among the X-rays there are some at the far end of the spectrum which are so highly penetrating that the walls and floors of our laboratories and cabinets present but slight obstacles, so that persons residing next them, whether as patients or as mere tenants, may become our innocent victims despite themselves.

"The gravity of this becomes apparent when we remember that recent researches in the treatment of cancer have shown that it is necessary to irradiate tumors for 12 or 15 hours consecutively with extremely penetrating rays. We may well ask ourselves, then, with the deepest concern what will be the fate of our neighbors on the floors below us at the end of a few months? And yet to secure protection from these dread effects is a comparatively easy matter: X-rays are absorbed by various bodies in direct proportion to their atomic weight and to the square of the mass. Now building materials have a very high atomic weight—*e.g.*, that of lime is 40.

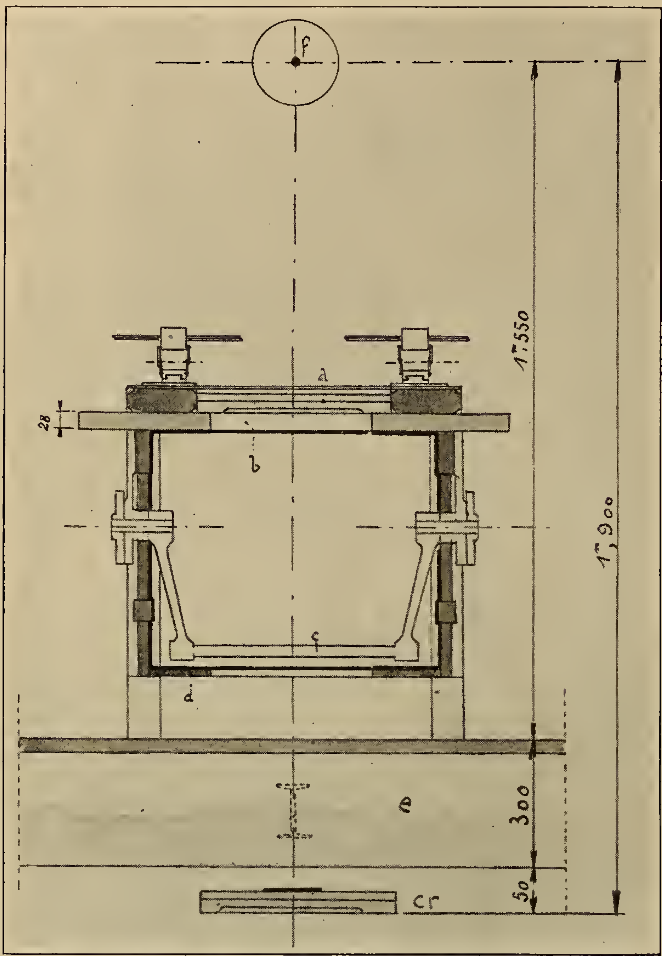
"On the other hand we have at our disposal as a means of protection a metal quite perfect for the purpose, namely, lead, which is not only cheap and readily obtainable by every one, but has the prime qualification of an atomic weight of 207.

"Our remedy, then, is merely to cover the walls and floors of our X-ray cabinets with sheets of lead whose thickness should vary from 6 to 10 mm., according to the power of the source of irradiation. This will remove all risk to our neighbors and our assistants, while as to the operators themselves, they should manipulate the apparatus from within a cabin encased in sheets of lead, observing their patients in a mirror."

After making this statement of his views M. Contremoulins urges that the handling of X-ray apparatus should be classed among the dangerous trades and its practice carefully regulated by law. At the same time he admits that his younger colleagues may raise strenuous objections to any sort of legal restriction. He hopes therefore to rouse the public to the dangers to which at present it is heedlessly exposed.

He justly observes that since the recent deaths of X-ray operators have occurred chiefly among those savants who began the study of the subject some 10 or 15 years ago, we should at least defer a final conclusion upon the matter for the same length of time, during which extensive experiment upon the matter should be made. Meanwhile it is the part of prudence to observe such precautions as may eventually prove indispensable, even if the danger be not yet fully proved. He observes: "Since I was among the first to experiment along this line, I shall all too probably meet the same end as my defunct col-

leagues, yet I hope that at least my own experience may serve as a warning to others. The searching behind a screen for the presence of foreign substances in a wounded soldier's body which I practiced during the war with only the army



ARRANGEMENT TO DETERMINE PENETRATION THROUGH THE FLOOR OF THE LABORATORY

f, coolidge tube; a, plate holder; b, marble, with lead facing; c, steel bar; d, lead sheet; e, floor and ceiling; cr, plate bearing test pieces

equipment at my disposal which did not afford adequate protection resulted in my being affected by an erythema of the hands, justifying my predictions and my fears.

"But I wish to emphasize that in my civil practice I have had no accident of any sort among my patients, my collaborator, my nursing staff, or myself, in spite of the enormous amount of work done in my laboratory, including from 70 to 100 examinations per day. The reason for this is that in 1912, after the death of Blanche Veinsan at Saltpêtrière, the board of directors finally granted me the lead sheathing for the walls for which I had been begging them for several years.

"This experience of 25 years is the best justification of my theories and I oppose it to the unfounded statements of my opponents, since the coffins of my unhappy colleagues have not sufficed to support my views."

DETAILS OF THE EXPERIMENTS MADE

"The installation of an operating room for radio-surgical purposes on the ground floor of my laboratory at the Necker Hospital, had as a result the exposure of my patients, of the nursing staff, and of the assistants in residence there, to the crossed radiations of three X-ray tubes operating simultaneously for several hours at a time. I deemed it advisable, therefore, to make experiments in order to determine what thicknesses of lead were necessary to insulate the two stories above from their radiations.

"I made use of a Coolidge standard X-ray tube and Jougela metro-radiographic sensitive plates, together with a reinforcing screen from the firm of Caplain-André which reduced the time required for exposure to one-twentieth that ordinarily required.

NATURE OF FLOOR AND CEILING

"The ceiling above was composed of iron beams and oak joists with a flooring which was likewise of oak; the ceiling underneath this floor consisted of plaster 10 cm. thick, the spaces between the joists being filled with rubbish. The total thickness of combined floor and ceiling was 30 cm.

"*First Experiments.*—The focus of the Coolidge tube occupied its usual place above the operating table 155 cm. above the ground. Under the floor at a distance of 190 cm. the radiographic carriage held the following test pieces: A piece of lead 3 mm. thick, Benoist radio-chromometer and a Contremoulins radio-photometer. In order to strike the surface of the sensitive plate the X-rays were obliged to traverse the objects enumerated below in the order of their distance from the focus:

"*a.* A slide-block and a plate-holder both of wood, having a combined thickness of 72 mm. and placed at a distance of 75 cm. from the focus.

"*b.* A portion of a marble slab 28 mm. thick covered with portion of the table, 135 cm. from the focus.

"*c.* A bar of steel 30 mm. in diameter, 130 cm. from the focus.

"*d.* A sheet of lead 3 mm. in thickness protecting the lower portion of the table, 135 cm. from the focus.

"*e.* The combined floor and ceiling described above.

"*f.* The test pieces held by the radiographic carriage which was placed at a distance of 190 cm. from the focus.

"Length of spark, 17 cm.; milliamperes, 2; time of exposure, 10 minutes. This is equal to a normal functioning of 2½ minutes with 8 milliamperes.

"*Result.*—The slide (*a*) yields no image. The sheets of

RESULT OF EXPOSURE THROUGH THE FLOOR

b and d, lead on marble; C, lead plate; e, steel bar; D, radio-chromometer; E, radio-photometer

lead (*b* and *d*) appear to be partially traversed; the sheet of lead (*d*) yields a clearly defined image of its edge underneath the portion protected by the marble and by the upper sheet of lead (*b*). The image of the radiophotometer is complete underneath the portion protected by the sheet of lead 3 mm. thick

and the marble (*b*); it is due in large part to direct radiation, judging by the clearly defined character of its edges. The steel bar (*c*) is traversed; the sheet of lead resting upon the chassis is cleary visible beneath its projection. An image which appears to correspond to that of an iron beam of the ceiling shows that the latter must have been powerfully traversed.

"We conclude that a mass of lead placed at a distance of 190 cm. from a 17-cm. spark Coolidge tube must not be less than 6 mm. in thickness in order to furnish effective protection. There should be no interruption of its continuity so that diffusion and secondary rays may be avoided.

SECOND EXPERIMENT

"The conditions of the first experiment remained the same in the case of the upper story. In the lower story the radiographic carriage was placed upon the table, whereupon the assistant arranged the plates during the functioning of the tube. This table was 460 cm. from the focus. The following test pieces were placed upon the carriage. At the corners pieces of metal of varying thicknesses (a piece of lead 3 mm. thick; a piece of steel 3 mm. thick; a piece of cast iron 100 mm. thick; an iron clamp). In the vicinity of the lead there was a shoulder blade. A dried skull rested upon the carriage base downward partly covering the piece of steel. In the center were the radio-chromometer and the radio-photometer. Upon the edge beneath the piece of cast iron and the shoulder blade there was a steel wrench.

X-RAY TUBE MOUNTED BEFORE THE OPEN WINDOW OF THE LABORATORY

"Length of spark, 17 cm.; milliamperes, 2; time of exposure one hour. This is equal to a normal functioning of 15 minutes with 8 milliamperes.

Result.—The sensitive plate, three-quarters of which was protected by the sheet of lead attached to the marble of the radiological table received an impression throughout its whole extent. This sheet of lead, 3 mm. thick allowed a portion of the direct radiation to pass; the piece of cast iron, the clamp, the radio-photometer and the wrench were clearly visible; the radio-chromometer yielded a faint image. Upon the portion of the plate which received the radiation filtered through the floor alone we could see very clearly defined the opaque mass of lead and the more transparent mass of steel. The skull yielded a perfect image through the latter. The shoulder blade was perfectly visible throughout its whole extent in spite of its very slight thickness.

"At this distance of 460 cm. and after being filtered through the floor the radiations which struck the plate were still easily absorbed, which is proved by the fact that it was possible to obtain the image of the shoulder blade. Obviously, therefore, they constitute a source of danger to the human organism.

"We know that photographic plates are but slightly sensitive to X-rays; apparently those X-rays which have very short wave lengths ought not to produce any impression. Hence, they escape registration by this graphic method. It would be advisable to seek for their presence by the more sensitive method of ionization.

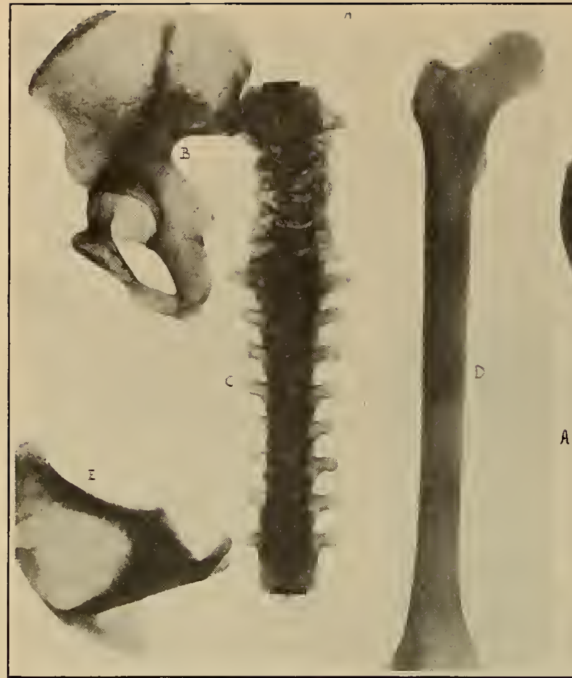
"For intensities which do not exceed 17 cm. in length of spark and 10 milliamperes, a lead casing 6 mm. thick placed at a distance of 2 m. from the focus would appear *a priori* sufficient. At any rate this is the minimum which should be exacted. These intensities correspond to those utilized in medical practice for the examination of patients (radiography-radioscopy).

"As for the intensities which are required in profound radio-therapy, in the treatment of cancer, they are represented in France by a length of spark of 25 cm. for from 12 to 15 consecutive hours of exposure, and in Germany by a length of spark of 120 cm. for 5 consecutive hours of exposure. The radiations produced by such potentials is endowed with a power of penetration which should probably be classed in the vicinity of the spectrum of radium. These sources of energy cannot be installed in the heart of cities without involving the gravest danger to their inhabitants. It is a matter of great urgency that proper measures should be taken to protect them.

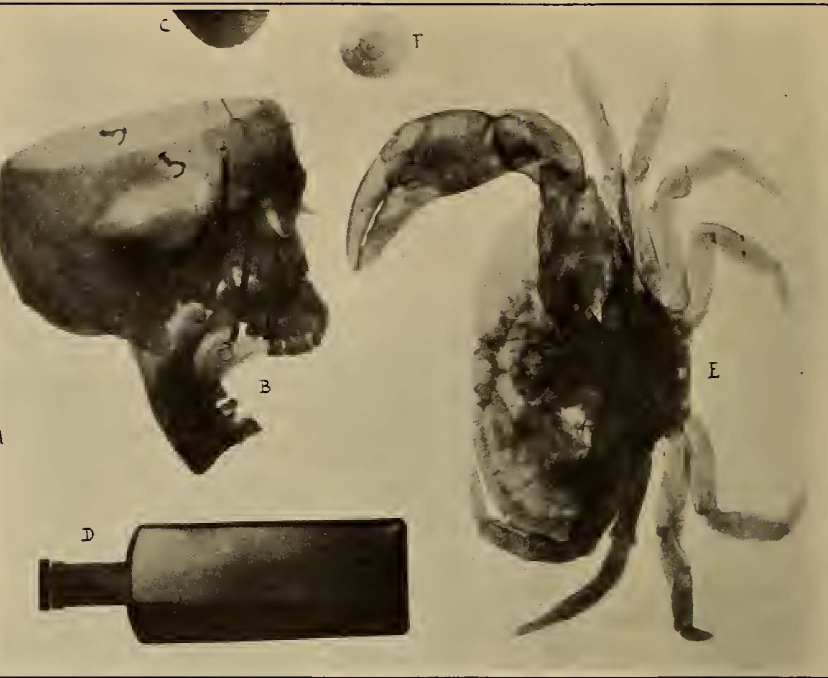
"I completed the researches above described[1] by making cer-

[1]Published in *C. R. Ac. Fr.* for May 2, 1921.

MAKING LONG DISTANCE X-RAY EXPOSURES. THE LOWER DOTTED LINE SHOWS AN EXPOSURE AT A DISTANCE OF 40 METERS (131 FEET) AND THE UPPER ONE AT 80 METERS (262 FEET)



RESULT OF AN HOUR'S EXPOSURE AT A DISTANCE OF 40 METERS



TELERADIOGRAPH OBTAINED AT A DISTANCE OF 80 METERS FROM THE X-RAY TUBE, WITH AN EXPOSURE OF FOUR HOURS

tain further experiments of which a brief résumé is given below:

"*First Experiment.*—I sought to find out whether it was possible to detect the presence of X-rays coming from one of my lamps behind the wall of a pavilion for patients placed opposite to my laboratory. I purposely selected the one at the greatest distance. This wall, which is 50 cm. thick, is built of brick and stone, and is situated at a distance of 15 m. from the focus of a standard Coolidge tube which irradiates it obliquely from an angle of about 40 deg.

"Radiation employed: Length of spark, 17 cm.; 2 milliamperes; time of exposure, 4 hours. The plate used was of the metro-radiographic type and is placed in contact with a reinforcing screen reducing to 1/20 degree. A strip of black paper interposed between the screen and the sensitive surface served as a control to eliminate the clouding due to the development. The plate presented a very apparent general impression *except for that part where the control strip of black paper was situated.*

"*Second Experiment.*—Two plates prepared as indicated above were exposed behind human bones and articles made of metal at a distance of 40 m. from the focus.

"Radiation used: Length of spark, 17 cm.; 2 milliamperes; time of exposure one hour. The plates yielded images which are correct and remarkably clear cut.

"*Third Experiment.*—A plate prepared as described above was placed behind a dried skull, a partly emptied crab, a glass bottle containing a solution of copper sulphate (30 per cent), a radio-chromometer, and a piece of lead 3 mm. thick. The ensemble was placed at a distance of 80 m. from the focus.

"The radiation employed: Length of spark, 17 cm.; 2 milliamperes; time of exposure, four hours. The plate yielded a correct image. These times of exposure were calculated from a standard photographic plate which received an impression at a distance of 2 m. in ten seconds, with a length of spark of 17 cm. and 2 milliamperes.

"It can be demonstrated that the negatives obtained at distances of 2 m. and of 40 m., respectively, are identical. That at 80 m. is fainter, but we must take into account the fact of the 24 minutes deducted from the normal time of exposure and the interposition of a fir tree situated at a distance of 20 mm. in the path of the rays.

"*Conclusion.*—It appears from the foregoing observations first that the range of the radiations emitted by tubes of the Coolidge type is quite considerable; and second, that they possess the property of being decomposed by the bodies which they traverse in comparable proportions, whatever the distance may be.

"It is evident, therefore, that the bundle of rays preserves in large part its initial heterogeneity since the images it furnishes of the same bodies are comparable at respective distances of 2 m., 40 m., and 80 m. At 40 m. a linen compress still yields a contrasting image.

"Under the conditions which we have just described there can certainly be no *a priori* denial that they exert a biological influence at a distance. The latter probably decreases in proportion to the density of the radiation, *i.e.*, according to the square of the distance."

A SERUM TO DECREASE WHITE BLOOD CORPUSCLES

At a meeting of the French Biological Society, held January 8, 1921, a description was read of an unusually interesting experiment made by M. G. Lindstroem. By injecting into the veins of a sheep white blood corpuscles or leucocytes taken from the abdominal cavity of a rabbit he obtained a serum, which when injected into the veins of the rabbit occasioned in this animal a marked diminution in the number of the poly-nuclear leucocytes and which even exerted a toxic effect when given in large doses. The author of the experiment observed, moreover, that the same leucolytic serum when employed in doses much smaller and often repeated, ceases to have an injurious effect but exerts a stimulating action upon the formation of the white corpuscles and even of the red corpuscles.

This interesting fact suggested the idea to M. Lindstroem that it might be possible, in two cases of pernicious anemia under his care, to excite the hematopoetic function of the spinal marrow in this way, but the attempts were without results. However, he was somewhat more successful in an attempt to treat the leucenia with a leucolytic serum prepared with the white blood corpuscles of two patients; the action of this serum when injected into the muscles was distinctly favorable for some length of time, but unfortunately the destructive effect of the serum proved to be only temporary, since at the end of three months the malady resumed its course.

The Fallacy of "Ptomaine Poisoning"

The Bacteria Which Are Really Responsible for Most Cases of Food Poisoning

By Frank L. Healy

IT is high time that justice were done the long-suffering ptomaines. For eighty years or more they have been made to bear, quite unjustly, the burden of responsibility for food poisoning outbreaks. Much has been done to exonerate the ptomaines, and to expose the real culprits, by Dr. William G. Savage, an English physician and public health officer, who has devoted many years to the study of food poisoning outbreaks and whose book "Food Poisoning and Food Infection" has recently appeared.

The history of the origin of the ptomaine theory of food poisoning provides a typical example of the fallacy of hasty generalization based on insufficient data. For this reason it might be worth while to consider how the theory arose and what discoveries led to its acceptance as an explanation of food poisoning; for this explanation certainly was generally accepted by medical men and scientific text-books, and the term "ptomaine poisoning" persists even today. Briefly the story is this: Certain scientists found in the early part of the 19th century that the injection of watery extracts of putrefying meat into the veins of various animals frequently produced death. They succeeded in isolating from putrid meat many chemical compounds which they found to be highly poisonous to animals by inoculation into tbeir veins. On account of their chemical similarity these substances were grouped together and called ptomaines. On the basis of these experiments the generalization was made that the ptomaines were responsible not only for the harmfulness of tainted meat, but for food poisoning in general. And even today, in spite of the existence of readily available evidence to prove the fallacy of this explanation, it is accepted as adequate by many medical men.

It cannot be too emphatically stated that the ptomaine theory has been definitely proved to be without scientific foundation as an explanation of food poisoning; and the reasons follow: In the first place, in most cases of food poisoning outbreaks, the food at the time of eating shows no signs of putrefaction, and is in no way offensive to the senses of taste or smell. The onset of symptoms occurs suddenly from three to forty-eight hours after the food has been eaten. It is patent that these symptoms could not have been caused by the presence of ptomaines in the food consumed, nor could they have been formed in the food after eating for the reason that ptomaines are end products of putrefaction. They are not formed in appreciable amounts until putrefaction has been in progress for a week or more, before which time the food has already become offensive to the senses. Certainly no person mentally normal would eat food which already showed unmistakable signs of decay as regards appearance, taste and odor. Furthermore, the general toxicity of ptomaines has been exaggerated. It was assumed, because these substances proved poisonous to animals when injected into their veins that they must also be poisonous to man when taken through the mouth. This assumption is not wholly justified in the light of feeding experiments which have been performed with ptomaines. Many of them can be eaten in relatively large quantities without producing toxic results. Among the ptomaines of this type can be mentioned methylamine which has been obtained from decomposing herring, haddock and other fish. Enormous doses of cadaverine when fed to dogs failed to produce toxic symptoms. As regards those ptomaines which have been found extremely toxic by injection, it has been found in the case of neurine that in order to produce the same physiological effect, ten times as great a dose was needed when administered by the mouth as when administered by injection under the skin. Muscarine, the toxic element in poisonous mushrooms, has a very similar action. These peculiarities suggest the existence of some agency in the gastro-intestinal tract capable of resisting the entrance of these ptomaines into the circulation. There remains the additional fact that the symptoms produced by taking ptomaines into the human body by the mouth are not those found in food-poisoning outbreaks. The term "ptomaine poisoning," then, is clearly incorrect when applied to food-poisoning outbreaks.

If ptomaines cannot be accepted as the cause of most food-poisoning outbreaks then what is the cause? This question can best be answered by a review of the development of the modern conception of the cause and nature of food poisoning. While the ptomaine theory still enjoyed wide acceptance, there grew up with it another conception based on the assumption that the food before eating became contaminated with bacteria capable of producing poisonous substances, known as toxins. Before proceeding further, a word about bacteria in general might not be out of place. The term bacteria includes all that vast group of one-celled fungi which reproduce their kind by fission, *i.e.*, by splitting. These micro-organisms, being members of the vegetable kingdom, obtain their food by absorption through the cell wall. When, therefore, a cell has grown to such a size that its surface area is no longer great enough to absorb sufficient food for the increasing bulk, the organism splits, forming two where but one grew before. Under favorable conditions it is possible for certain bacteria to produce one of their kind every twenty minutes. In the course of the metabolism of the food ingested certain groups of bacteria produce substances which are harmful to man. These poisonous substances are called toxins, and each toxin is the specific product of a definite bacterium. It might be mentioned that the bacteria capable of producing substances harmful to man are far outnumbered by those which are quite harmless.

Returning now to the original this bacteriological conception of food poisoning the first important investigation in which a causal connection was established between a definite bacterium and a case of food poisoning was carried out by Gaertner in 1888. At Frankenhausen, in Germany, a cow suffering from enteritis was killed. The flesh of the cow which appeared quite normal was consumed by several people who fell ill with the usual symptoms of food poisoning—severe abdominal pain, diarrhœa, vomiting, followed by prostration. One of those affected died. Gaertner succeeded in isolating *Bacillus enteritidis* both from the fatal case and from the organs of the cow. Since that date this bacillus, or bacilli closely related to it, have been isolated from a large number of food-poisoning outbreaks, and the responsibility of this group of organisms, known as the *Gaertner* or *Salmonella* group, for the great majority of food-poisoning outbreaks has been definitely established.

There are, of course, other causes of food poisoning beside *Gaertner* group bacilli, but these make up only a small minority. For example, cases of food poisoning known as *botulism* have been shown to have been caused by the infection of the food by *bacillus botulinus.* Sausages and canned foods—fruits, vegetables and fish—are usually the vehicles, and carelessness in preparation is usually responsible for the condition. The abnormal state of the food can be detected, however, before eating since the toxin produced by *B. botuliuns* imparts to the food a distinctly rancid odor and taste. Moreover, thorough cooking effectively destroys the toxin. *Botulism* is comparatively rare in this country except on the Pacific coast, accounting for only a small percentage of the food-poisoning outbreaks. Food-poisoning outbreaks resulting from the pres-

ence of poisonous chemical substances in the food, whether introduced unintentionally in the process of manufacture or intentionally for the purpose of preserving or coloring the food, are comparatively infrequent and will not be considered here. It can be said, therefore, that bacterial infection by members of the *Gaertner* group of bacteria can be accepted as the cause of the great majority of food-poisoning outbreaks.

One is naturally curious to know the kinds of food which most commonly act as vehicles of infection and the way in which they become contaminated. A study which Dr. Savage made of 112 outbreaks, occurring in Great Britain between 1880 and 1918 seems to place the greatest responsibility on flesh foods. In 21 cases the vehicle was a non-flesh food: Milk 9, cream 1, ice cream 6, potatoes 2, pineapple jelly 1, canned peaches 1, rice cooked in fat 1. The remaining 90 cases were caused by the consumption of flesh food: 37 by meat pies and potted meats made from beef or pork, 27 by unprepared meats such as pork, beef and ham, 19 by canned meat and fish; 2 by sausages, 1 by pickled meat, 4 by internal organs. It is interesting to note that the flesh of the sheep is almost never the vehicle of infection, probably because sheep are so little subject to diseases caused by bacilli of the *Gaertner* group. The general conclusion, then, seems to be that, in the great majority of these outbreaks, prepared meat foods, principally the flesh of the pig, the cow, or the ox, are the vehicles of infection. This is not difficult to understand when we consider that prepared meat foods contain large quantities of jelly, which is an admirable nutrient material for bacteria, in fact is used by the bacteriologist in his laboratory for the artificial cultivation of bacteria.

The question naturally presents itself: How then do these foods become contaminated with the bacillus whose toxin is the direct cause of most food-poisoning outbreaks? In a certain number of cases the source is straightforward, the vehicle being meat or milk derived from an animal suffering from a disease caused by one or another of the members of the *Gaertner* group. In other cases the most probable source of infection seems to be animals or insects which have the opportunity of contaminating human food. In support of this contention it may be mentioned that Dr. Milton J. Rosenau, professor of preventive medicine at Howard Medical School, at a conference of State Health Officers held at Saratoga Springs, N. Y., in November, 1920, asserted that, after three years of experimentation at Boston it had been found that ptomaine poisoning as such does not exist, but that food poisoning in the modern sense of the word is due chiefly to infection of food by disease carriers. It has been found that rats and mice are susceptible to diseases caused by bacilli of the *Gaertner* group—particularly worthy of mention is mouse typhoid, which is caused by a germ known as *Bacillus typhi murium.* This bacillus, which is pathogenic to man, is often harbored in the animal intestine for long periods after the animal has recovered from the disease. During this period, in which the animal is acting as a carrier of the disease, it has ample opportunity of infecting human food with its excreta. Moreover, there are on the market and in wide use rat and mouse exterminators which consist of bacteria belonging in the *Gaertner* group. It is true that these viruses, as sold, are not pathogenic to man, but there is some foundation for the belief that they may become pathogenic to man after repeated passages through rats or mice. There is, besides, the additional fact in support of the carrier idea, that flies infected with *Bacillus enteritidis* carry it in their crops for seven days at least, during which time they have many opportunities of transmitting the bacteria to food intended for human consumption.

There only remains in conclusion to outline a few of the means which may be employed to combat the bacterial infection of food and food-poisoning outbreaks resulting from it. In the first place, the medical profession should take a greater interest in this subject and discard, once and for all, the discredited ptomaine theory. In the second place, great care should be taken to locate food preparing plants outside the slaughter house and at a considerable distance from it. Furthermore, a high standard of cleanliness should be enforced wherever prepared meat foods are made, since these lend themsleves most readily as vehicles of infection. In this connection it would be well to obtain more exact knowledge as to the extent to which rat and mouse viruses may be converted into strains virulent to man, and to regulate their distribution. Finally the classic warning, of course, remains unchanged: "Swat the fly."

WHY BRANCHES SPREAD IN DIFFERENT DIRECTIONS

At a recent session of the French Academy of Sciences, Oct. 18, 1920, a note was offered by the botanist, M. H. Ricôme, concerning the phenomenon of the spread of the branches of trees and plants in various directions. The author remarks that geotropism results from modifications in the growth determined by the force of gravity. It would appear that an organ possessing radiate symmetry could have no other direction than a vertical one from the force of gravity alone, yet, as we know, branches orient themselves in every direction. This geotropism is explained by M. Ricôme as being the result of an inequality in the growth of the cells. It would appear that any such inequality, no matter how slight it may be, ought to cause the growth to occur in a curved line, but branches grow in straight lines.

The orientation of branches is evidently affected, however, by the amount of water at their disposition. In any system of branches the higher the branch the more difficult the ascension of the water to it. But the higher the location of the branches the less the effect of gravity upon them, since the amount of water obtainable is more scantily distributed. However, if the axis be cut the branches will tend to erect themselves in a greater or less degree; if they be detached from the parent plant and their base be immersed in water they will assume a vertical direction. It is obvious, therefore, that they all possess the same property that the stalk has of an ascending vertical geotropism. But this property is unable to manifest itself while they are still growing on the parent stem, by reason of the fact that they cannot obtain the necessary quantity of water.

The influence exerted by the quantity of water is thus explained by M. Ricôme: The two halves of a stalk which is split lengthwise will curve abruptly toward the outside by reason of the unequal tension exerted upon the tissues—this is what is known as the *force of tension.* In each section of the curvature and at each point of the curve (ignoring the influence of neighboring incisions) the orientation forms a resultant between two forces of tension, which are opposite and which are unequally modified by the force of gravity.

The amount of turgescence depends upon the quantity of water contained in the cell. If the quantity of water be sufficient, the branch will erect itself under the continuous action of gravity until it assumes a vertical direction.

But if the quantity of water is merely sufficient to fill the cell it is retained therein by osmosis, by the elasticity of the membranes which imposes upon the cell a definite form which is capable but of slight modification, by capillary phenomena, and by the cohesion of the water. Gravity will not dispose of any quantity of water which can be distributed unequally. The organ is not affected by the gravity and takes the direction indicated by its mode of insertion upon the stalk, or the direction which is given to it artificially.

If the quantity of water at disposal for the unequal distribution is limited, the action of the gravity will cease as soon as the said distribution is accomplished. At this moment each of the two forces of tension has a value proper to itself, whereby there results a given direction of growth—this is the direction which the branch takes and to which it inevitably returns if its position be changed, since this is the position of equilibrium of its growth under the given condition.

Grafting and Evolution

Is the Success of Grafting a Criterion of the Relative Parentage of the Species?

By Lucien Daniel

Professor of Agricultural Botany at the University of Rennes (France)

THE Ancients maintained that it was possible to graft to each other two vegetable plants very dissimilar in character. The Moderns treated these affirmations as legends and thought they could show that grafting is only possible between species of one order or between species of different orders but belongisg to one family. Now the Ancients made use of both Siamese or parabiose grafting (Fig. 1) which consists of a simple fusion of tisues, and ordinary or olobiose grafting (Fig. 2) which determines a mutual parasitism more or less complete in the grafted plants in addition to the preliminary fusion of the tissues.

We can understand that success with these two types of symbiosis is not obtained with equal facility and that the manner in which the physiological functions of each conjoint are put into practice is by the no means the same in the two cases. It has been shown to-day, experimentally, that it is possible to obtain parabioses between plants very differently classified, such as the cabbage and the tomato, for example, but such anatomical combinations cannot be changed into ordinary grafts without causing the death of at least one of the grafted plants. It follows from this that the Ancients and the Moderns were right according to their points of view. They made a mistake in not thoroughly defining their subject and their disagreement comes from the fact that they gave the same name to combinations very different in nature.

FIG. 1. PARABIOSI OR SIAMESE GRAFTING OF TOMATO AND GILIA (*POLÉMONIACEÆ*)

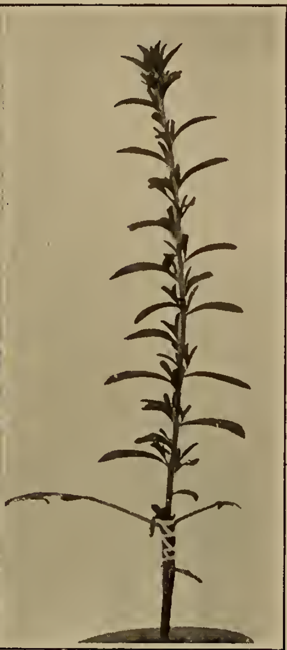


FIG. 2. OLOBIOSIAN GRAFT OF STEIRA PURPUREA AND XANTHIUM

When it is a question of ordinary grafts, almost exclusively employed in every-day practice, their success has almost always been confined to the family to which they belong, and often, in the majority of cases indeed, successful results have only been obtained between species of the same class. It is this which led de Candolle to consider successful grafting as the true criterion of the relative parentage of groups and species and to recommend the use of grafting as a means of solving the much disputed question of classification. This was to subordinate the reproductive characteristics, until then considered as dominant, to the anatomical and physiological characteristics, to which the naturalists generally attach very little importance because they vary so readily under the influence of changes of surroundings.

Now this criterion has not the importance thus attributed to it and experiments have proved it clearly. One single fact thoroughly proved in actual practice would suffice to show it.

The pear-tree is easily grafted on the quince-tree but the quince-tree cannot be grafted on the pear-tree. In these two types of grafting the parentage of the species has remained unchanged. This example is not unique. There are other ligneous and herbaceous plants, the inverse graftings of which do not succeed with equal facility.

Besides it is sufficient to try a grafting of two species more or less separated and taken from classes of different groups belonging to the family, in order to show that the success of the operation has no close connection with the parentage of the species. Although we are unable to state the exact cause, there are in one family and sometimes in one class, convenient species which graft easily, and other species more independent which will accept a dual life with difficulty, and which die rather than enter into contact with a strange plant.

Among the genus *Solanum* the species which lends itself most

FIG. 3. GRAFTING OF *PHYSALIS FRANCHETI* ON *SOLANUM MELONGENA* (EGGPLANT)

Two fruits of the eggplant can be seen on the twig left on the graft-supporter. The graft has many characteristic fruits

readily to symbiosis is the tomato. It grafts not only with species of the genus *Solanum* but also with the *Atropa*, *Physalis*, *Nicotiana*, *Nierembergia*, *Petunia*, *Datura*, *Lycium* etc.

In other words it grafts with herbaceous or frutescent plants, annual or perennial, with cycles of development very different from its own. The case is almost identical with tobacco and eggplant, which allow their graftings to reach normal height (Fig. 3). However, certain species belonging to the Cestrum and Fabiana classes refuse to live in common with the tomato. Others, however, produce very antagonistic associations, growing with difficulty and destined to a premature death. This is the case of pimento whether it serves as subject plant or as a graft. It is, however, with the tomato that

it succeeds the best (Fig. 4) but the latter yields no fruit even in the case of the most successful graftings.

The thorn-apple and the deadly night-shade are not so exacting as the pimento, but they are capricious at times. Grafted on the datura the tomato grows splendidly. The deadly night-shade grafted on the datura under the same conditions develops poorly and produces plants more or less weak according to the specimens taken (Fig. 5).

It is often the case also with the potato, which, in certain cases, is reduced to a tubercule which caps the plant in a very curious manner. The inverse grafting of the datura on the potato succeeds better as a rule, and the plants form a varying number of tubercules. However, the tomato, the potato, and the deadly night-shade are three species of the genus *Solanum*, closely related which ought to take with equal facility on the datura.

In the family of compound plants, anomalies still more pronounced and still more curious are to be found. We know that the *Xanthium Strumarium* belong to the Ambrosiaceæ related to the compound plants. But certain botanists have called it Urticacean, and others have placed it in the category of the Heliantheæ and consequently in the compound plants. It was therefore a case in which to apply the principle of the botanist de Candolle to this much disputed phenomenon. Now it happens that *Xanthium* like the tomato, is a plant which lends itself easily to grafting and unites with plants very different in nature. For example it can be grafted on the *Vernonia praealta*, and the *Stockesia cyanea* which are *Vernonieae*, with the *Stevia purpurea* which is a *Eupatoriea;* with the *Helianthus, Cosmidium, Cosmos, Ximenesia,* and *Bidens* which are Heliantheae; with the *Artemisia camphorata* which is an *Artemisieae*, etc. In which of these categories therefore are we to place it? This is not all. In one single group, that of the Heliantheae for example, it is far from succeeding with equal facility on species belonging to neighboring classes and for this there is no apparent reason.

Thus the *Heliantheii* grafted on *Xanthium* hardly grow at all and bear no flowers. The *Tagetes* and the *Madaria* remain stunted but produce flowers and bear fruit (Fig. 6); the *Cosmos* develop fairly well although they remain smaller; the *Bidens* on the contrary become very rich (Fig. 7).

These examples show that even when ordinary grafting only is used, successful grafts taken as a criterion of parentage would result in very strange groupings contradicting the best suppositions already established by means of the natural method. Among the plants the anatomical and physiological parentage which determines the success of grafting does not always coincide with the parentage of reproductive organisms which forms the basis of our classifications at the present day.

During the last few years much stress has been laid on the principle outlined by de Candolle, in order to establish the parentage of some of the higher animals with man. The excellent research work of Dr. Carrel is known in connection with animal grafting, and we know also that he succeeded in placing in the human body organisms belonging to the moneky, the dog, the sheep and the cow. The parts taken from the monkey did not take nearly so well as those taken from the other three animals and as a result of which the following conclusions were drawn:

"The most recent scientific discoveries tend to reject Darwin's theory rather than to confirm it. For many years many men with great scientific knowledge have declared that the analogy existing between the human structure and that of the monkey, proved directly that the former must be a more advanced variety of the family to which both belong. According to their theory, generation succeeding generation, brings about in the anatomy of the monkey modifications and improvements which bring the quadrumane gradually nearer and nearer the human type.

But the science of physiology and anthropology takes up a different point of view. It considers the formation of different tissues and glands, their resemblance, their natural longevity,

FIG. 4. TOMATO GRAFTING (*SOLANUM LYCOPERSICUM*) ON PIMENTO (*CAPSICUM ANNUM*)

The graft bears one fruit and has not branched out

FIG. 5. GRAFTING OF DEADLY NIGHT-SHADE (*SOLANUM NIGRUM*) ON PIMENTO

Potato graftings (*Solanum tuberosum*) on Pimento are shown at left

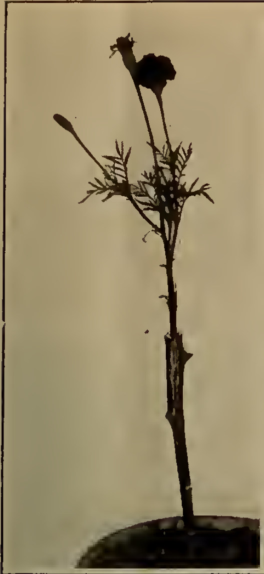


FIG. 6. GRAFTING OF *TAGETES ON* XANTHIUM

FIG. 7. GRAFTING OF *BIDENS CERNUA* ON XANTHIUM STRUMARIUM SHOWING A VERY RICH AND FULL DEVELOPMENT

FIG. 8. POTATO GRAFTED ON TOMATO, BEARING TUBERS ABOVE GROUND

their aptitude for growth, when transformed to another being, as the fundamental basis of all comparative study. Now this method once adopted as the true criterion of reasoned study, it is absolutely impossible for man to have ever had for this prehistoric ancestor a monkey of any kind."

I have not, in this article, to give a decision for or against such and such hypothesis concerning the descent of the human race. But the results which have just been indicated concerning the Parabioses (anatomical grafts) and ordinary grafts (anatomical and physiological grafts) show that the criterion fixed cannot be applied to vegetable plants. It is quite possible that the same thing may be said in connection with animals. However interesting the graftings of Dr. Carrel may be, however strange certain vegetable fusions may be, we must not give them a philosophical importance or bearing which they do not possess. Scientifically they leave untouched the anxious problems of the origin and the evolution of the species.

A NEW METHOD FOR GROWING PLANTS

In the *American Journal of Botany* Dr. J. M. Brannon describes an interesting new method for growing plants.

In growing plants under sterile conditions, says the author, investigators have employed either agar cultures or some other substratum of solid or semi-solid character placed in culture tubes, or else they have used water or soil cultures. In the water or soil cultures the roots only are maintained sterile, leaves and stems being exposed to the atmosphere.

In the course of investigations on the organic nutrition of plants, the author noted at various times that seeds would germinate and seedlings would grow even when entirely immersed in a liquid medium. As a result it was decided to test the possibility of using such liquid cultures for the investigations. Striking successes were obtained, and the superiority of this method for growing plants in the dark over the agar method or the water culture methods was at once apparent.

In a flask or culture tube, the size depending upon the plants to be grown and upon the duration of the experiment, is placed the culture solution. The depth of the solution should not exceed six centimeters. The vessels are plugged with cotton and then autoclaved. The seeds to be sown are then sterilized and the desired number sown in the culture solution. In the work reported by the author the seeds were sterilized by the calcium hypochlorite method of Wilson. This method of growing plants has been used with flax, alfalfa, corn, pea, and timothy. These were all grown in the dark.

The special advantage of this method is in the fact that the plants used will live and grow for a much longer period of time than by the other methods. It would seem, in the case of plants grown in the dark, that the sugars are either too slowly absorbed by the roots or that conduction of the sugars is too slow to satisfy the needs of the plant.

Another advantage over the agar method is the greater ease of analyzing the solution. In the agar method the agar must first be removed before the sugar determination can be made. Absorption phenomena inadvertently play a part in the precipitation of agar, thus another source of error is introduced.

THE LIFE OF THE CELL

The capacity for functioning possessed by the body depends upon the delivery of nutritive substances to the cells, since it is these which not only build up the organs but, moreover, are intimately connected with the nervous impulse which is twofold in each cell—exciting and inhibiting. In each organ and demonstrably in each cell a double system of nerve fibers leads to the nucleus (the nucleim body, chromosome) the one springs from the original organizer of all living substance, namely, the sympathetic nerve system—*Nervus sympathecus.*

A recent German writer, Carl Schleich, calls this great sympathetic nerve, on account of its mysterious and unknown origin in the rhythm of the universe "The Marconi plate of the Universe" and he expresses the concept that all so-called intuitive impulses inexplicable antipathies and sympathies, forebodings, ideas of inventors, mediumistic and super-intellectual capacities, etc., are connected with the metaphysical functioning of the *nervus sympathecus.*

The other guiding system directing the inner activities of the cell springs from fibers coming from the later developed central nervous system (brain and spinal column). It controls the capacity for industrial orientation—the expression of the personal will, while the *Sympathicus* is the bearer of the race-will. The central nerve system is the forward, striving, exciting the rouser of the cell's activities.

It represents the dynamics of the double nervous system upon which the hormones secreted by the internal secretion glands make their presence felt. The shriveling or the reconstruction of cells, their atrophy or their overgrowth (hyperplasia) are the result of the interplay of these two cell registers.

Thus we can readily understand how the hormones both excite and inhibit. The hormones of the puberty gland stimulated by Steinach's process causes the entire system of cells to become once more capable of regeneration. . . . And so he attains artificial adolescence.

New Facts About Red Corpuscles*

Studying the Blood Cells by Methods Suggested by Colloid Research

By Dr. Bechold

"THE living organism is a complicated piece of watch work." This often heard comparison does not quite hit the mark, for when but one tooth of a gear wheel is broken out of a watch, the latter either stops or its movement is disordered. But from even the highest organism, that of man himself, very considerable portions can be abstracted without very gravely affecting the organism. Thus, both legs, one of the kidneys, or a portion of the intestines can be taken away without too serious results. There is, to be sure, a difference in vital importance of the various tissues of the body. The muscle of the heart is more important than that of the arm and certain portions of the brain are more important than the peripheral nerves. From this point of view the *blood* must be ranked as one of the most vitally important organs, for if a considerable portion of this fluid be lost, life itself ceases. And in the blood it is the corpuscles which play the most important rôle.

We shall here confine ourselves to a discussion of the red blood corpuscles or *erythrocytes*, as they are called from the Greek words *erythros* for red and *kytos* for cell. Since the white blood corpuscles or *leucocytes* (*leukos* is the Greek for white) do not enter into the problems with which we expect to deal in this article, we shall omit further mention of them. In human blood the red blood corpuscles have an average diameter of about 0.007 mm. and in a healthy man there are about 5 millions per cubic millimeter while in that of a woman there are about 4.5 millions per cu. mm.

The knowledge and the study of the blood and especially of its corpuscles is of the greatest significance in medicine. A physician estimates the number of the red blood corpuscles in the blood of a patient and also studies their tint, concluding that anaemia is present if they are much below par either in color or number.

Blood is a yellow liquid within which float the disc-like red corpuscles which lend it their hue. Besides the color and the number of these bodies their form offers valuable information, especially in a group of grave diseases which include leucamia, many infectious diseases, and cases of chronic poisoning. Hitherto the study of the blood corpuscles has been attempted by the microscope alone. The expert haemotologist placed a drop of blood upon a glass slide and observed it through the lens of his microscope, which revealed that it contained a number of pale yellow discs, to form a judgment of whose condition required both a keen and a well-skilled eye. The corpuscles are much more readily observed, however, if they be colored artificially. The method of doing this medical science owes to Paul Ehrlich.

The simplest animal cell. The red blood corpuscle is regarded as the simplest form of cell present in the body of an animal. For purposes of study it possesses the advantages over other cells, that it can be conveniently taken from the body and subjected to observation and experiment so as to find out the nature of its behavior under the most various influences. The information thus gained from the study of red blood corpuscles is considered applicable—whether the opinion be correct or not does not matter here—to the other cells and unions of cells or tissues. On this account there is no part of the body that has been more carefully studied than the red blood corpuscles, whose conduct forms the basis of what we know respecting what happens in the tissues of men and animals under normal and under diseased conditions, under the influence of poisons and of medicines, and under the conditions of self defence against injuries, *i. e.*, of immunity.

*Translated for the *Scientific American Monthly* from *Die Umschau* (*Frankfurt*), for May 28, 1921.

One might well think from this recital that we now possess extremely exact knowledge as to the structure, properties, and behavior of the red blood corpuscles, but this is by no means the case. We know that they contain about 62 per cent. of water and that in the water about 32 per cent haemoglobin is dissolved (estimated from the total corpuscle).

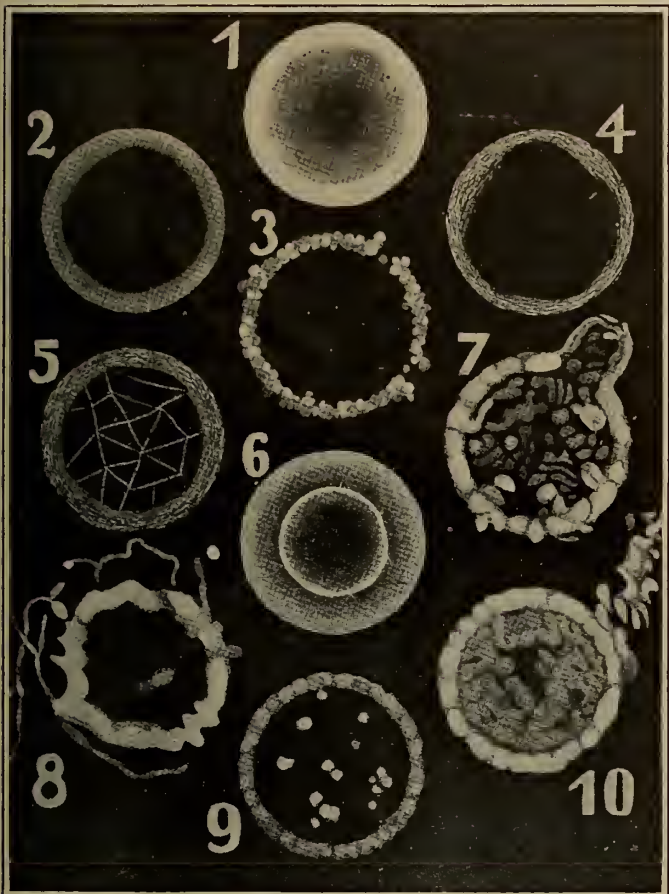
Haemoglobin. Haemoglobin is the red coloring matter which takes up the oxygen in the lungs. The blood corpuscles also contain from 0.4 to 0.7 per cent of fatty constituents, known as lipoids; these are composed of two kinds of materials: A wax-like body called a cholesterin, and a fat called lecithin which swells when placed in water, forming an emulsion with the latter; lecithin contains phosphoric acid. The blood corpuscle also contains a number of salts which are never lacking in the remainder of the organism; these include sodium chloride, potassium chloride, calcium compounds, etc.

When the red corpuscles are separated from the rest of the blood, the plasma, they can be preserved a longer time if they are placed in a solution of salt and water containing the salts in the same degree of concentration in which they are present in the blood. This solution is called Rinerg's solution. For most purposes, however, what is known as phsyiologic salt solution, which consists of water containing 0.85 per cent of ordinary cooking salt will suffice. The floating mass is brilliantly red and non-transparent (opaque in color). If it be diluted with pure water it may be seen under the microscope how the separate cells swell, and if the solution be still further thinned there finally comes a moment when they entirely disappear. This can be recognized as taking place in a test tube by the fact that the floating blood begins to become more transparent until, finally, the tube contains an entirely transparent fluid of a beautiful shade of red. The blood has become a "lac dye." This process is termed getting a "blood solution" or *haemolysis*. As we shall see later this expression is not quite correct, for we never obtain a true solution in the chemical sense of the word, as we do for instance when we dissolve sulphate of copper in water. Another experiment also shows that not all the elements have gone into the solution. If such a "blood solution" be briskly centrifugated so as to make it fly out of the tube, there will remain at the bottom of the latter bits of white film. When haemolysis takes place under the miscroscope to all appearance everything vanishes; by making use of an artificial coloring matter, however, it can be demonstrated that a very delicate film remains behind which is identical with the bits of film obtained in the tube. These very delicate films or skins are known as "shadows" or *stromata*.

These observations, together with the aspect of the blood corpuscle under the microscope, have led to various attempts at the formation of a plausible concept with regard to the structure of such a blood cell. Hitherto opinions have differed widely in respect to this matter. It formerly was supposed that the blood cell was a sort of bubble with a fluid content (haemoglobin solution) and surrounded by an envelop of albuminous matter. These enclosing envelops or skins were supposed to be the source of the stromata mentioned above. Somewhat later the opinion prevailed among some students that the stromata constitute a sort of sponge in which the haemoglobin solution is absorbed (either with or without a protecting envelop). The process of haemolysis presents peculiar difficulties to investigate. The explanation which found favor at any given time reflects, indeed, the current physical and chemical theories in their application to questions of biology and physiology.

When the doctrine of *osmotic pressure* entered upon its vic-

torious course some thirty years ago, it was hailed by those who believed they found in its application to the processes of haemolysis a peculiarly convincing example in the domain of biology. If a solution of sugar be placed in an unglazed porous clay cell, whose pores are of such a size that water can pass through them, but not sugar, then the following phenomena are observed: If the cell be immersed in water, water will pass through the walls to the inside so that the solution of sugar will be diluted. If, on the other hand, the cell be placed in a more highly concentrated solution of sugar, then water will pass from the inside to the outside of the clay wall, so that the solution in the cell will become more concentrated.



RED BLOOD CORPUSCLE AND ITS SOLUTION OR HAEMOLYSIS UNDER THE ULTRA-MICROSCOPE

1. Intact red blood corpuscle. 2. Stroma. 3. Division of the periphery into grains (cholesterin is brightly luminous and lecithin faintly so). 4. Remainder of the stroma after removal of the lipoids. 5. Diagram of the stroma. 6. Formation of a concentric ring at the beginning of the haemolysis. 7. Beginning of haemolysis in sublimate (1/20,000 sol.); note blister-like projections. 8. Tube-like projections made under thê influence of sublimate (1/20,000 sol.), 9. Final stage of haemolysis by water. In the inside are dancing balls of cholesterin. 10. Hardened corpuscles with a "ball of wool" structure and escape of clotted haemoglobin under influence of sublimate (1/2,400 sol.).

This exchange of water between the two solutions always takes place except when the osmotic pressure on both sides of the clay wall is the same, *i.e.*, when there is a like concentration both within the cell and outside of it. If the wall used in the experiment is not rigid, as it is in the case of a clay cell, then the inflow and outflow of the water can be recognized by the corresponding swelling or shrinking of the cell. This process can be observed admirably in blood cells. In solutions which are more dilute than physiological salt solutions, *i.e.*, in *hypotonic* solutions, the blood corpuscles swell, but if they are placed in *hypertonic* solutions, *i.e.*, in those which are more concentrated than physiological salt solutions they shrivel and assume peculiar jagged forms which are called "thorn apple" forms (from the fruit of the stramonium). From these phenomena the conclusion was drawn that the blood corpuscle possesses a "semi-permeable" skin like the clay cell described above, *i.e.*, a skin or envelope permeable to water but not to the substances dissolved therein; it was supposed that this envelop was composed of albumenoid bodies: And furthermore, that when the pressure became too great, *e.g.*, in pure water, the corpuscle burst and allowed the haemoglobin solution to flow out. But in spite of the coincidences in the phenomena observed there are some contradictions which make it impossible to accept such an explanation. Chief among these is the fact discovered that this envelop or cell wall is permeable to many dissolved substances; but for the processes of swelling and shrinking to take place a condition of semi-permeability, *i.e.*, an absolute exclusion of everything except water, is a requisite condition.

A theory has been formulated by Overton and Hans H. Meyer, according to which each cell is supposed to be surrounded by a lipoid membrane, that is, by an envelop of a fatty nature. This would allow only those substances which are soluble in lipoids to penetrate the cell. The main object of these investigators was to find an explanation for the phenomena of narcosis. They were able to prove that narcotic substances, such as ether, chloroform, chloral, etc., exert a narcotic effect in direct proportion to their solubility of fats. The thought readily occurred that this theory might be extended so as to apply to other cells, such as blood cells; it is a fact that fat dissolving substances, *e.g.*, certain dye stuffs, are capable of penetrating them. This suggested the idea that the envelop of the blood corpuscle contains lipoids. Since, as we have said above, red blood corpuscles are known to have a content of from 0.4 to 0.7 per cent of lipoids, this theory appeared to have much in its favor. However, it is contradicted by the fact that many substances which are soluble in water but *not* in lipoids are capable of penetrating blood cells. Nathanson sought to find a way out of this dilemma by the concept that each cell envelop may have a sort of mosaic structure, being composed partly of lipoids, partly of cholesterin (which is incapable of swelling) and partly of a semi-permeable albumenoid material. Such a cell envelop was supposed to answer the requirements insisted upon by Höber to the effect that the cell must possess some sort of contrivance enabling it to regulate the "import" and "export," so to speak, of building materials and waste matter. The mosaic structure suggested by Nathanson was a hypothesis which other investigators accepted with more or less modification, but for which no convincing proof is given.

This was the position of the question when the present writer, a professor in the Institute for Colloid Research at Frankfort, a.m., together with a number of distinguished colleagues, Messrs. K. Hattery, W. Kraus, S. Neuschloss, and E. Salén took up the question afresh.[1]

EXAMINING BLOOD CORPUSCLES BY THE ULTRA MICROSCOPE

The ultra microscope in combination with the arc light offers possibilities of detecting details far beyond the power of the ordinary microscope. Furthermore, one can dispense with the dyes necessary in the ordinary microscope, whose use, moreover, always involves a chance of error. Then, too, the methods employed in the study of colloids offer new paths for approaching the present problem.[2]

[1]Bechhold. Structure of the red blood corpuscles and haemolysis (in German). *Munch. Med. Wochenschrift,* 1921, No. 5.

[2]Vide also Raehlmann (*Deutsch Med. Wochenschrift,* 1904, No. 29; Loewit). *Ziegler's Beitr,* Vol. 42 (1908), p. 559, etc., and especially A. Dietrich (*Arb. d. Path. Inst. z. Tübingen,* Vol. 6 (1908), p. 375, etc.; and Proceedings of the German Pathological Society, all of which articles have thrown much light on the obscure field of the red corpuscles. The latter also holds because of these experiments that the red corpuscle consists of a bubble-like envelop with a homogeneous content of haemoglobin. The definite proof thereof, namely, "the dancing spheres" is lacking. The explanation of the structure of the envelop and of the process of haemolysis was first made possible by the methods of colloid research applied by ourselves to this subject.

To begin with, E. Salén took up the problem as to the structure of the stromata.[3] In the ultra microscope an intact blood corpuscle has the aspect seen in Fig. 1 (all the figures, shown are much conventionalized); after the conclusion of the process of haemolysis the stromata remain and are recognizable as a faintly shining ring (Fig. 2). The process of haemolysis takes place in such a manner that according to the conditions of the experiment the shining edge of the disc is dissolved into grains as shown in (Fig. 3) or else a ring separates from the periphery and contracts concentrically (Fig. 6) until it has formed one or more spheres (Fig. 9) which dance hither and thither in the interior of the disc.

In the meantime there was a short period during which the blood corpuscle was extinguished, while Fig. 1 changed into Fig. 2. Obviously this is the instant during which the haemoglobin solution flows inside the cell towards the outside.

Salén then decomposed the remaining stromata with different solvents successively. From these investigations it was learned that the stromata consist of an extremely delicate, readily stretched framework not unlike a cobweb in appearance (Fig. 5); the edge of this framework is stiffened by fibrillae on the periphery (Fig. 4). The spaces between these tiny fibers bound together like a cobweb are plainly filled with lipoids. It is this structure which somewhat resembles that of a balloon net which makes it possible for the blood cell to swell when placed in a hypertonic solution; this also explains the formation of the so-called "thorn apple forms" which occur when the blood corpuscle shrivels upon being placed in more highly concentrated solutions.

The possibility considered above of an inside framework on scaffolding, is weakened by the fact that in many cases of haemolysis the dancing balls make their appearance in the interior (Bechhold and Kraus).[4] This is naturally not to be reconciled with the idea of an inner framework.[5]

The *part played by the lipoids*, the cholesterin and the lecithin, in the blood corpuscle was peculiarly obscure. As we have said, Salén's experiment showed plainly that these substances fill the meshes of the framework. As we can see clearly, even in Fig. 2 the stromata are almost black, only the edge gleaming with a dark glow. Lecithin, indeed, is but faintly luminous in the ultra-microscope, but cholesterin, on the other hand, is distinguished by its intense luminosity. When we recall that cholesterin is *always* found in company with lecithin in the blood corpuscle, we see why it was so hard to understand the reason for the darkness displayed in the ultra-microscope.

But a highly surprising explanation of this circumstance was yielded by the experiments by Hattory[6]: *in the swollen lecithin the cholesterin forms a colloidal solution*, and as such it presents a dark aspect in the ultra-microscope; not until there is a *separation* of the two so that the cholesterin stands apart from the lecithin does the former appear in the form of brightly shining, dancing spheres or balls (Figs. 3 and 9), while the latter forms a droplet shining with the faint gleam peculiar to itself. Further researches made by Bechhold and Neuschloss[7] next showed that a swollen lecithin possesses an uncommonly low surface tension, that it has a tendency to spread itself out upon surfaces, and that as a result of this property the meshes of the protein framework inevitably fill up in the same manner that the meshes of wire gauze become filled by soap bubble films.

Here it seems probable that we have a definite explanation of a structure of the blood corpuscles, which may be described as follows: It consists of a net-like swollen framework of protein, whose meshes are filled by the lipoids, *i.e.*, by a colloidal solution of cholesterin in swollen lecithin. This bubble-like envelope encloses the salt containing solution of the blood pigment, the haemoglobin.

But these investigations also yielded an explanation of the nature of *haemolysis;* the colloidal solution of cholesterin in swollen lecithin remains unaltered when placed in physiological solution. If, however, they be placed in water or in hypertonic salt solutions (*i.e.*, those of lower concentrations) then a separation of the cholesterin and the lecithin takes place. Hence we see that the normal state of the envelop of the blood corpuscle is conditioned by the equilibrium that obtains between the swollen framework of protein and the colloidal of cholesterin in lecithin. If one of the three components be altered or abstracted from the union, then the envelop becomes permeable to the content of liquid haemoglobin, whereupon haemolysis occurs. The case is exactly similar to that which we find in ceramic masses: The clay vessel and the glaze thereupon must have the same coefficient of expansion, since otherwise the glaze cracks off and the vessel ceases to be water-tight.

When we test the various substances which exert a haemolytic effect we find a confirmation of the above statements. It is a well known fact that blood corpuscles will dissolve when either heated or frozen; the reason for this is that these physical factors also occasion an unequal alteration of the condition of swelling or expansion of the lipoid mixtures and of the protein framework. Concentrated solution of the neutral salts (such as table salt, sulphate of ammonia, etc.) as well as dilute solutions of the salts of heavy metals, precipitate albumen and, therefore, cause a shrinking in the expanded framework of protein and thus bring about haemolysis, as we have long known. The solutions of heavy metals, such for example, as sublimate, must, therefore, be extremely dilute, otherwise they will precipitate the haemoglobin also in the blood corpuscle and the latter will, apparently, remain unaltered. Under the ultra-microscope the fact that this precipitation has taken place is recognized by the structure, which resembles a piece of knitting as shown in Fig. 10, in which figure we also see some of the haemoglobin appear which, however, is immediately clotted. Previous stages (in more dilute solutions of sublimate) are seen in Figs. 7 and 8 where we are able to recognize the alteration which has taken place, especially of the outer envelop: blister-like projections and the tube-like so-called "myelin forms."

Solutions which dissolve fat, most of which also coagulate albumen and which, therefore, have the effect of separating the lipoids from the framework of the albumen, must necessarily produce haemolysis and this is also proved by tests made with ether, alcohol, cholesterin acid salts and chloroform. There are not only reagents which precipitate albumen but others which precipitate the swollen lecithin; these include, for example, saponin, the well known substitute for soap made from the so-called soap bark or quillaya bark and these also occasion haemolysis.

These experiments show plainly that it is not the alteration of the osmotic pressure, as such, which is the controlling factor in the process of haemolysis, as has so long been thought. Rather has it been demonstrated that haemolysis is the result of the separation from each other of the three constituents which are united to form the envelop of the corpuscle, namely, the protein framework, the lecithin and the cholesterin.

Every influence which affects unevenly the condition of expansion of the protein framework or of the lecithin, must result in haemolysis, as likewise any sort of attack which alters the state in which the cholesterin is dissolved in the lecithin.

FINAL REMARKS

It is exceedingly probable that the conditions which we have thus found to obtain in the case of the blood corpuscle are also effective to a greater or less extent in that of other cells, such as those of bacteria, plant cells, and the cells of organic tissues.

[3] E. Salén. *Biochem's Zts.* 110 (1920), p. 176.

[4] Idem, 109 (1920), p. 226.

[5] Now that the nature of the constituent non-soluble in water is known I propose to call it merely by the name of *envelop* or *membrane*, instead of by the earlier names of *stromata, shadows, discoplasma*, or *oikoid*.

[6] *Biochem. Zts.*, 1921.

[7] *Kolloidzeitschrift*, 1921.

Gorillas, Champanzees and Orang-Utans

Some New Observations on the Characteristics and Habits of the Man-Like Apes

By May Tevis

Illustrated with photographs from the New York Zoological Society

AT the head of the animal kingdom stand the primates. Some authorities indeed consider that man himself is merely one genus of the primates. The superior members of this great class are known as the man-like apes. As we shall see they bear a close resemblance to human beings anatomically and in various other ways. Even in their mental qualities there are points of resemblance, for example, they are imitative, so much so that the very word ape has acquired a secondary use as a verb meaning to imitate; again they are intensely curious and man, as we know, is the most curious of all animals—perhaps, indeed, it is not too much to say that it is this quality of curiosity which has led him ever onward and upward along the steep paths of knowledge.

In aspect, too, the primates strongly suggest man, especially the men of the less developed races. Strange to say, however, this resemblance does not add to their beauty nor make them more attractive to man. On the contrary there is nearly always something grotesque or even repulsive in this similarity, while some specimens fill us with a sense of shuddering disgust, suggesting some hideous and devil born caricature of mankind. This likeness, by the way, is much more marked and at the same time less repellant in the young animals than in the adults. This is partly due to the fact that the ridges of the skull are not developed so as to accentuate the difference, while another is that the bodies are nearly naked of hair like that of man. Mr. Carl E. Akely, associate of the American Museum of Natural History, told the writer recently that he had seen in the London Zoo some years ago a baby gorilla which was quite startlingly human in its appearance. Paul du Chaillu even goes a step further in his famous book of travels. He states that he was greatly astonished upon capturing a female Chimpanzee with a young one clinging to her to find that the face of the latter was as white as that of a European child, although the mother's face was black. His surprise greatly amused the negroes with him and they said to him facetiously "Here is your little white friend, Chelly. When we catch a gorilla you say to us 'Look at your black friend,' now we say to you, 'Look at your white friend.' Look at your little white cousin of the forest, it has straight hair like you, too. It looks much more like you than the gorilla does like us. The gorilla may be black like us, but it hasn't got wool on its head, and the chimpanzee has a face like you and hair like you, too." Whereupon they all burst into roars of laughter. Du Chailiu accepted the joke amiably and replied, "Yes, but he has a flat nose like yours, and when he grows up his face will be black, too"—remarks which increased the general hilarity of the natives.

Probably, however, it is the intelligence of apes, large and small, and the resemblance of many of their habits to those of human beings that makes them always objects of interest and even fascination to mankind, though they are seldom either admired or loved as are dogs and horses.

The Anthropoid, or man-like apes, may be separated from the lower apes as a group, Simiæ, or as a family Simiidæ, which has the following distinctive characters:

Though tree-living creatures for the most part, these apes, when they come to the ground, move in at least a semi-erect fashion. When they put their hands upon the ground to aid in walking, they do not rest as do the lower apes upon the flat of the hand, but upon the back of the fingers. None of the anthropoids has a tail, or cheek pouches. There is commonly a laryngeal pouch which is of large size, and aids in the production of the voice which is usually very loud. The hair is rather more scanty than in the lower apes. The placenta differs in detail from that of the lower apes, and is exactly like that of man. Their arms are longer as compared to their legs than in the lower apes and they have a vermiform appendix to the cæcum. In the latter but not the former character they agree with man. The anthropoid apes are entirely Old World and dwellers in the tropics at the present time.

The Gibbons, genus *Hylobates*, stand quite at the base of the series of existing anthropoid apes. They are the smallest and the most purely tree-frequenting of all the members of that group. In the skull the chief noteworthy character as compared with the other anthropoids is the fact of the large size of the canines which are of equal or nearly equal size in the two sexes. The molars on the other hand have been particularly compared to those of man. The brain is simpler than in the higher forms. But it is not clear that this may not be a case of diminished complexity of convolution going hand in hand with smallness of size, according to the Cambridge Natural History.

Of gorillas, genus *Gorilla*, there is but one species, which must apparently and rather unfortunately be called *Gorilla gorilla*.

The external aspect of this great anthropoid is familiar from many reproductions. The male, as is usual, is larger than the female, and his characters are more pronounced.

The face is naked and black, and the skin generally is deep black, even at birth. The ear is comparatively small, and lies close to the side of the head; it is altogether more human in form than that of the Chimpanzee, and this statement applies also to the rudimentary condition of the muscles of the ear which are more rudimentary than in the Chimpanzee. The nose has a clearly marked ridge in the middle and the nostrils are very wide. The hands and feet are short, thick, and broad; the fingers and toes are webbed. In the foot the heel is more apparent than in other anthropoids; it is not, however, so marked as in man. The hair upon the head forms a kind of crest which can be raised when the animal is angered. The neck is thick and short, and the beast has massive shoulders and a broad chest.

If it were not for the fewness of the Anthropoid apes and their nearness to man it is doubtful whether the gorilla would be ranked as a distinct genus (it is not so ranked by everybody), for in internal structure it is very near the Chimpanzee.

The cranial capacity of the gorilla is greater than that of the chimpanzee. It is not possible, however, to decide from this point of view whether a given skull is that of one or of the other of these apes. Some chimpanzee skulls are higher in capacity than some gorillas. But the average is undoubtedly as stated. It is to be noted that there is an inverse ratio between cranial capacity and size of plate, *i.e.*, the greater the brain the smaller the palate. This applies to man as compared with his ape-like relatives, but does not apply so accurately to the gorilla, which has a more extensive palate than the chimpanzee; its "brute development" is much greater than that of the chimpanzee. Not only is the palate larger, but the molar teeth, slightly different in form, are also larger and stronger. This is so plainly marked that "one may say almost with certainty, that any upper molar tooth over 12 mm. in length is that of a gorilla, and under

12 mm. is that of a chimpanzee." In the skeleton generally it may be said that the crests for muscular attachments upon the bones are greater in the gorilla. The nasal bones are much more like those of lower apes in their length, and they have a sharp ridge more marked than in the chimpanzee, which, however, disappears in aged animals. It is a curious fact that gorillas often have a "cleft palate," owing to the failure of the palatal part of the palatine bones to meet completely. The general conformation of the skull is less brachycephalic in the gorilla.

The limbs show a number of small differences, which are associated with a more completely arboreal life in the chimpanzee as compared with the gorilla. The latter is approaching the human way of life. In spite, however, of these differences, no hard and fast lines of divergence can be laid down between the two African Anthropoids, for it appears from the many memoirs that have been written upon both that "there is scarcely a feature in any muscle or bone found in one animal which is not also found in the other." The heel of the gorilla has already been referred to. This is, of course, associated with a plantigrade, earth-walking habits of progression.

SUZETTE, THE FAMOUS CHIMPANZEE, WHO WAS FORMERLY A VAUDEVILLE PERFORMER

YOUNG GORILLA "IN THE HANDS OF HIS FRIENDS" IN THE NEW YORK ZOOLOGICAL GARDENS

Certain of the muscles of the calf of the leg attached to the sole show a more human arrangement in the gorilla than in the chimpanzee. It is interesting to find that the muscles of the little toe are diminishing in the gorilla as in man. This is most clearly due to its habit of walking on the ground. The arm of the gorilla is less adapted to tree-traveling. Its proportions differ from those of the arm of the chimpanzee in that the fore-arm is shorter. In both animals the thumb is not of much use, and this digit is more retrograde in the gorilla, not only in proportionate length but in its muscles. The hip girdle tells the same tale. It is broader in the gorilla, and the glutaci muscles are more prominent, all these features being connected with the more erect gait.

The brain of both animals has been studied, but not from many gorillas. On the whole, the gorilla has the larger brain, but this must be discounted by the fact that it also has the larger body. It is a remarkable fact that the gorilla's liver is much more like that of the lower ape than the liver of the other anthropoids. It has, as has the chimpanzee, laryngeal sacs. The general conclusion concerning the relative position of the two African Anthropoids seems to be that the gorilla is the more primitive; and as thus it must approach more nearly to the original parent than does the chimpanzee; it may be said that it also comes rather nearer to man, since the chimpanzee has traveled away from the common stock on another line. The detailed likeness to man, however, mainly comes from a tendency to walk in the same manner.

In mental characteristics there is the widest difference between the two apes that we are considering. The chimpanzee is lively, and at least when young, teachable and tameable. The gorilla, on the other hand, is gloomy and ferocious, and quite untameable. When angry the gorilla beats its breast, a statement that was originally made, we believe, by M. du Chaillu, but which has been disputed, though it appears to be perfectly true. A young gorilla exhibited in the gardens of the London Zoo could be observed to do so. The cry of the chimpanzee is different from the "howl" of the gorilla. An immense amount has been written upon the ways of this animal in its own home, including much that is legendary. The gorilla has been said to lurk in the depths of the forest, and to stretch down a prehensile foot to grasp and strangle an unfortunate black man passing below. It is said, too, to vanquish the elephant by hitting it hard upon the trunk with a stout stick and to crumple up the barrel of a rifle with its powerful teeth.

The gorilla is limited in its distribution to the forest tract of the Gaboon. It goes about in families, with but one adult male, who later has to dispute his position as leader of the band with another male, whom he kills or drives away, or by whom he is killed or driven away..

It feeds upon the berries of various plants, and upon other vegetable food; there is apparently not so marked an inclination for animal food as is exhibited by the chimpanzee. In search of their food they wander through the forest, walking partly upon the bent hand, and progressing with a shuffling gait. It is noteworthy that the gorilla has been said to walk upon the palm of the hand and not upon the back, as is the case with the chimpanzee. It can readily assume the upright position and, in this case, balance itself largely with its arms. Professor Hartmann, however, states that the back of the hand is also used. Unlike most or many wild beasts, the gorilla exhibits no desire to run away when he views a human enemy. Dr. Savage remarks that "when the male is first seen, he gives a terrific yell, that resounds far and wide through the forest, something like kh-ah! kh-ah! prolonged and shrill. When making an attack the gorilla rises to his feet, and as a full-grown animal reaches a height of some five feet, he is a most formidable antagonist. The attack of one of these animals is said to be made with the hand, with which he strikes his adversary to the ground, and then uses the powerful canines. The beating of the breast which heralds an attack is a statement made by M. du Chaillu.

The chimpanzee, genus *Anthropopithecus* (or Troglodytes) are to be distinguished from the gorilla by the characteristics mentioned above. Briefly summed up they are mainly as follows: The ears are large, and generally stand out from the head; but there are exceptions to be noted presently. The coloring of the body is not always so deep as in the gorilla. The nasal bones are shorter. The skull as a whole is more brachycephalic, and the molar teeth are smaller. The hands and feet are much longer, the animal being more purely arboreal than the gorilla. The female chimpanzee is slightly smaller than the male, but there is less difference than in the gorilla. The animal, like the gorilla, has large air sacs.

Chimpanzees are entirely restricted to Africa, and though they appear to extend rather farther east than the gorilla, the forest-clad region of the equatorial belt is their home.

It has been mentioned in treating of the gorilla that the main feature of this animal, which affords a constant difference from the chimpanzee is its gloomy and ferocious manner. The chimpanzee, on the other hand, is lively and playful, though often maliciously so, and quite tameable, as many instances—particularly that of "Sally" of the London Zoo—show. The earliest mention of animals that are probably

chimpanzees is to be found in a work upon the Kingdom of Congo published in 1598.

The Orang-Utan, genus *Simia*, has but one definable species, viz., *S. satyrus*. The supposed species of Owen, *S. morio*, cannot be satisfactorily defined. Plenty of other specific names have also been given to what is in all probability but a single species of large anthropoid ape inhabiting the islands of Borneo and Sumatra.

The name Orang-Utan, now applied exclusively to the subject of the present description, was formerly applied also to the Chimpanzee, and to that animal, moreover, under the Latinized version of *Homo sylvestris*. The orang is a large and heavy ape with a particularly protuberant belly and a melancholy expression. The face of the old male is broadened by a kind of callous expansion of naked skin at the sides. The color of the animal is a yellow brown. The ears are particularly small and graceful and lie close to the head, which is very broad. The arms are very long, and when the animal stands they reach the ankle. It is a curious fact that the head of the thigh bone is unattached by a ligament to the socket of the pelvis in which it articulates, a state of affairs which may give the limb greater freedom in movement, but does not add to its strength.

This ape inhabits flat and forest-clad ground, and lives mainly in the trees. The male leads a solitary life except at the pairing season, but the female goes about with her family. On the ground the orang walks with no great ease, and uses his arms as crutches to swing the body along. Even on trees the rate of progress is not rapid, and is accomplished with careful investigations as to the capabilities of the branches to bear his weight. The "Man of the Woods" has been stated to build a hut in trees. This is hardly true, but it does build a tree-nest.

One of these nests has lately been described by Dr. Moebius. It was found on the fork of a tree 11 meters above ground. Every night as it appears, or every second night, the animal constructs a new nest for himself, abandoning the old one. So numerous, therefore, are these nests in localities frequented by orangs, that a dozen can be readily found in a day. The particular nest which Dr. Moebius examined was 1.42 meters long, and at most .80 meters broad. It was built of about twenty-five branches, broken off and laid for the most part parallel to each other. Above the framework a number of loose leaves lay. There is no doubt, therefore, that these nests are not by any means elaborate and that they only serve as sleeping places and not as nurseries.

WHILE NOT A SKILLED TYPEIST "TILLIE" ENJOYS THE NOISE HER MACHINE MAKES

The orang seems to be usually of a fairly mild disposition; it will rarely attack a man unprovoked. But Dr. Wallace describes a female orang who "on a durian tree kept up for at least ten minutes a continuous shower of branches, and of the heavy-spined fruits as large as 32-pound shells, which most effectually kept us clear of the tree she was on. She could be seen breaking them off and throwing them down with every appearance of rage, uttering at intervals a loud pumping grunt, and evidently meaning mischief. The name given by the Fyaks to the orang is Miss Pappan."

This habit of occupying a nest for only a night or two appears to be general among the man-like apes. A German

AS THIS PICTURE INDICATES THE ORANG-UTAN IS AN ACCOMPLISHED ACROBAT BUT A POOR PEDESTRIAN OWING TO THE PECULIAR STRUCTURE OF THE HIP JOINTS

naturalist in Africa has recently published some unusually interesting observations made by him personally with regard to the nests of gorillas and chimpanzees. He remarks that the former may be regarded as the real inventor of the spring mattress by way of a bed!

THEIR FOOD

All of these apes live chiefly upon vegetable food. This is said to be diversified, however, by an occasional bird or small animal, while all monkeys are very fond of eggs, their arboreal habits making the robbing of birds' nests an easy matter for them. On a recent visit to the beautiful grounds and magnificent collection of animals of the New York Zoological Society in Bronx Park, near New York City, the writer questioned one of the keepers in the house of the primates concerning the food of these animals in captivity. He replied that they were practically as omniverous as man himself. The bulk of their food consists, of course, of fruit and cereals, particularly of the tropical fruit such as bananas, oranges and cocoanuts, to which they are accustomed in their native haunts. But they also eat bread and milk with relish and are occasionally given boiled beef or chicken by way of a special treat and for the sake of variety in the diet.

A lady of the writer's acquaintance once had rueful cause to remember that monkeys are fond of birds! While wearing a new bonnet adorned with a bird she approached a cage of monkeys to watch their gambols, when one of them suddenly thrust his hand through the bars, snatched the bird from her bonnet and instantly began to pluck it with great zest.

The monkeys in the New York Zoological Gardens are fed twice a day, at 2:30 and in the evening shortly before they retire, the latter meal consisting only of milk or bread and milk. It is amusing to watch them when the keeper opens the

THE HAND AND THE FOOT OF A CHIMPANZEE

Note the length of thumb and shortness of fingers of the hand, also the thumb-like character of the big toe and the naked sole of the foot

rear door of the cage and sets in the dish of supper. Sometimes they drink their milk from the bowl standing on all fours with the dish resting on the floor of the cage, but more commonly when the keeper remarks "supper is served" or words to that effect, they climb down from their lofty perch, grasp the dish in one hand, holding it level so as not to spill the precious fluid, and climb with the other three limbs back to their aerial station and seat themselves comfortably so that they can hold the bowl in both hands while drinking its contents. One of the big chimpanzees at the Zoo seems to enjoy dipping his bread in the bowl of milk and then sucking it luxuriously until the liquid has disappeared, and an amusing story is told of some monkeys in a collection of animals kept, we believe, at the Soldiers' Home in Dayton, Ohio, which when given slices of bread and butter, would calmly lick off the butter and hand back the bread for more.

THE ART OF MIMESIS

Next to the faculty of curiosity that of imitation is perhaps the most marked characteristic in the intelligence of simians. It is this quality, as we have said, which is most often held up to scorn in apes and monkeys, as is evidenced by such popular expressions of derogation as "aping one's betters," "playing monkey-tricks," "playing the sedulous ape," etc. But rightly considered this faculty, too, holds within its compass the seeds of progress toward better things. It was by "playing the sedulous ape" to his betters that Stevenson acquired his delightful style. Aristotle declared that the very essence of "Epos making and the making of tragedy, also comedy and dithyramb making, and most fluting and harping are . . . but imitations," and in commenting upon this Professor Gilbert Murray declares that man's ancestors from their tree-dwelling days onward stood out from all other animals by their marvelous powers of mimesis, and it was in this power coupled with the capacity for choice that he finds the real secret of their advance in knowledge and skill above the other beasts of the field.

Writing in a recent number of the *Yale Review*, he utters the following remarkable words concerning these primordial forebears of ours:

"When they met with a sort of conduct which they liked they had the power of imitating it, and, of course, the power of selecting for imitation the particular element in it that happened to appeal to them most. Sometimes they imitated badly and chose the wrong things; sometimes they seem like our poor relations in the Zoological Gardens today, to have imitated without any coherent plan or choice at all. But on the whole there has been a coherence in the main stream of human mimesis; we have imitated the things which we admired. . . . We have formed ideals, and our ideals have guided us. It is this power of idealism, this curious power of seeing what we like and admire and then trying to imitate it; of seeing things that were beautiful and trying to make others like them; of seeing things that roused interest or curiosity and trying by mimetic imagination to get inside them and understand them that has been the guiding force in the upward movement of humananity."

A PRIMARY CLASS FOR PRIMATES

The most intelligent of the man-like apes now in the New York Zoological Gardens is the large chimpanzee, Suzette, who is respectfully referred to by her keepers as a retired vaudeville actress, from her exploits upon the stage where only a few years ago she was a star performer upon the tight rope and bicycle. When the writer last saw Suzette she looked as sedate, however, as she does in the accompanying picture. It was about six o'clock by daylight saving time in the evening of a beautiful spring day, but in spite of the broad daylight which still prevailed Suzette, after finising her supper caught up an armful of straw in her left arm from the bottom of her cage, swung herself skilfully "upstairs" by her right hand, added the straw to the bedding already on her bunk and, drawing the drapery of her couch about her, lay down to pleasant dreams.

But the bright particular ornament of the primate house was the late-lamented Susie, the apt pupil, first of Professor Furness of Philadelphia, and then of the late Dr. Garner. Apropos of Susie's proficiency one of the keepers relates an amusing tale. After remarking that the great apes vary much like children, not only in intelligence but also in their proclivity for mischief making, he said that a few years ago the experiment was made of having Susie go through her

"stunts" before seven other chimpanzees, then owned by the Society. These seven little chimpanzees would be seated on chairs watching Susie, like good children "minding teacher," when suddenly little Dick, Susie's mate, and the most mischievous and least tractable of the lot, would jump from his seat, dart behind the row of attentive pupils, snatch the chair from beneath one of them and fly back to his place looking as solemn as an owl and as sober as a judge.

MAN AND THE MAN-LIKE APES DESCENDED FROM A COMMON ANCESTOR

Modern zoologists and anthropologists have come to the conclusion that man is not descended from any of the anthropoids but that *Homo* and his cousins, the great apes, have sprung from some common ancestor in the remote abyss of time. We cannot do better here than quote the conclusions stated by Gregory.

(1) Comparative anatomical (including embryological) evidence alone has shown that man and the anthropoids have been derived from a primitive anthropoid stock and that man's nearest existing relatives are the chimpanzee and gorilla.

(2) The chimpanzee and gorilla have retained with only minor changes, the ancestral habits and habitus in brain, dentition, skull and limbs, while the forerunners of the Hominidæ, through a profound change in function, lost the primitive anthropoidal habitus, gave up arboreal frugivorous adaptations and early became terrestrial, bipedal and predatory, using crude flints to cut up and smash the varied food.

(3) The ancestral chimpanzee-gorilla-man stock appears to be represented by the Upper Miocene genera *Sivapithecus* and *Dryopithecus*, the former more closely allied to, or directly ancestral to, the Hominidæ, the latter to the chimpanzee and gorilla.

(4) Many of the differences that separate man from the anthropoids of the *Sivapithecus* type are retrogressive changes, following the profound change in food habits above noted. Here belong the retraction of the face and dental arch, the reduction in size of the canines, the reduction of the jaw muscles, the loss of the prehensile character of the hallux. Many other differences are secondary adjustments in relative proportion, connected with the change from semi-arboreal semi-erect and semi-quadrupedal progression to fully terrestrial bipedal progression. The earliest anthropoids being of small size doubtless had slender limbs; later semi-terrestrial semi-erect forms were probably not unlike a very young gorilla, with fairly short legs and not excessively elongate arms. The long legs and short arms of man are due, I believe, to a secondary readjustment of proportions. The very short legs and very long arms of old male gorillas may well be a specialization.

(5) At present I have no good evidence for believing that the separation of the Hominidæ from the Simidæ took place any earlier than the Miocene and probably the Upper Miocene. The change in structure during this vast interval (two or more million years) is much greater in the Hominidæ than in the conservative anthropoids, but it is not unlikely that during a profound change of life habits evolution sometimes proceeds more rapidly than in the more familiar cases where uninterrupted progressive adaptation proceed in a single direction.

(6) *Homo heidelbergensis* appears to be directly ancestral to all the later Hominidæ.

PECULIARITIES IN THE SKIN OF NEGROES

The skin of negroes varies from that of Europeans in certain important particulars and we are justified in concluding as a result of careful observation that its method of functioning is likewise different. Even when the temperature of the air is quite high the negro skin continues to feel cool; in spite of its dark color it suffers no injury from a solar irradiation sufficiently strong to raise blisters upon the white man's skin. Moreover, blacks appear to have an unusual sense of well being when in the sunshine. It is only exceptionally that one sees sweat collecting in drops upon their faces, but that there is an invisible perspiration present is made known by the peculiar and penetrating odor which proceeds from the skin. This appears to be due to a fatty acid allied to one of the butric acids and contrary to the general opinion it is entirely unconnected with personal uncleanliness; it is said, in fact, that not only do scrupulous ablutions fail to remove this odor but they even seem to make it all the stronger as soon as any violent muscular activity is performed.

This scent varies in strength in individuals. The skin of negroes seems to exercise the function of an excretory organ to a greater degree than does that of Europeans and the circulation of blood through it also appears to be more vigorous. A striking property of negro skin is its turgidity; it appears to be unusually thick and possesses a characteristic consistency which causes it to yield to pressure without feeling actually soft. The texture is coarser than that of the skin of Europeans and the ridges and grooves of the epidermis are more clearly defined, while even in the case of young people there are faint impressions like shallow furrows or cracks which change here and there into small wrinkles with advancing age. The surface of the skin often has an appearance of being slightly granulated, because of the prominence of the papillæ and the shallow dimple formed hollows between them. In contrast to the full, plump skin of the Bantu negro that of the Hottentot looks dry and withered. Even at a not very great age it tends to form wrinkles which causes persons still in middle life to seem quite aged. In really old persons this wrinkled aspect increases so much as to accentuate the ugliness of the face. At first very tiny wrinkles appear which can be plainly seen only on those parts of the body where the skin is very loose. Very soon, however, these small wrinkles begin to form groups and deep secondary wrinkles are formed which, finally, degenerate into actual furrows upon the skin and neck. These minute folds in the skin appear so early and in such abundance that they cannot be ascribed to declining age but must be regarded as a normal property of the skin of Hottentots. The Hottentots, however, are not afflicted with the peculiar penetrating odor which proceeds from the skin of African negroes.

The skin of the Bush folk is likewise remarkably dry from youth on and it has a peculiar texture which more than anything else resembles that of tanned morocco leather. Furthermore, just as the leather has lost a part of its elasticity from being tanned, so the skin upon the living body of the Bushman appears already to have become less elastic for on those parts of the body where it is subjected to a temporary stretching as in the neighborhood of the knee, the armpit, or the abdomen, it does not immediately spring back but falls into deep folds. While the formation of folds in the skin of the Hottentot represents a wrinkling which is less dependent upon the part of the body concerned and which is probably due chiefly to the early disappearance of the fatty tissue, in the Bushmen the elasticity of the skin itself is lost. Accordingly even the finest lines upon the surface of the skins of the two races differ from each other. While in the Hottentot the small folds run into the furrows of the skin, in the case of the Bushmen the skin has a much more irregular texture covered with broad cracks so that it resembles somewhat badly mishandled leather, whether the person is walking or standing. The main direction of these scarlike depressions by no means coincides with the longitudinal direction of the folds in the skin, but generally runs off from the latter at one or another obtuse angles.—This peculiarity may be seen even in the children of so-called domesticated Bushmen living upon farms. In fact this scarred and leathery aspect of the skin is seen even in boys about 13 years of age.—Translated for the *Scientific American Monthly* from the *Ntw. Umschau d. Chem.-Ztg.* (Berlin), for April, 1921.

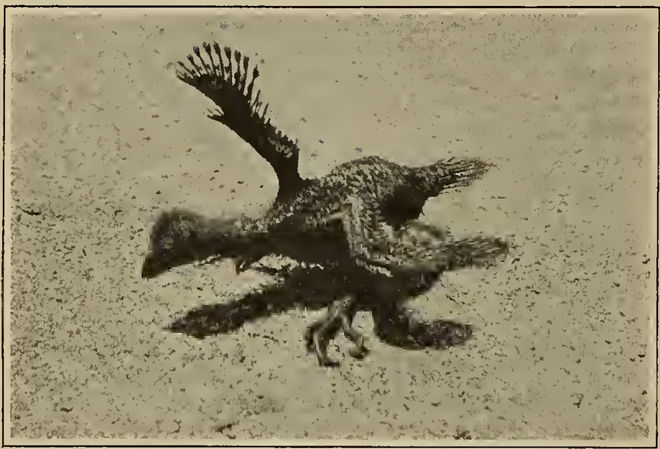
Four Legged Birds That Climb Trees

The Hoatzin—A Missing Link Between Birds and Reptiles, Found in South America

By Donovan McClure

Photographs by Dr. C. William Beebe

ONE of the strangest birds in the world—a survival indeed from an earlier zoological age—is the graceful crested pheasant, found in British Guiana and known by various names, including the native term hoatzin derived from its harsh cry, not unlike the raucous scream of a guinea fowl; other names applied to this strange bird are "Anna," "Hannah," "Canje," pheasants, Governor Battenberg's turkeys, the loco bird or "crazy" bird, the cigana or "gypsy" bird, and most unpleasant of all the "stinking" pheasant.



A YOUNG HOATZIN SCRAMBLING ALONG THE GROUND

Distribution and Description.—This bird is widely found throughout South America, the countries where it has been observed including Colombia, Ecuador, Peru, Venezuela, Bolivia, Brazil, as well as British and Dutch Guiana. The bird was first described more than 250 years ago by Hernandez, in his Latin work "*Nova Plantarum, Animalium et Mineralium Mexicanorum Historia.* He is described' in the following words:

"This is a bird of about the size of an Indian fowl; its beak is curved; its breast shades from white to buff; its wings and tail are spotted with white at intervals of a thumb's length; the back of the upper part of its neck is yellow, shading into blackish on both sides and sometimes extending as far as the beak and eyes; the claws are black and the legs blackish. The bird bears a sturdy crest of feathers, varying from white to yellowish, the back of each feather, however, being black. The bird subsists upon snakes. It has a powerful voice, which resembles a howling or wailing sound. It is heard in the autumn and is held inauspicious by the natives.

"The bones of this bird relieve the pain of wounds in any part of the human body; the odor of the plumage restores hope to those who, from disease, are steadily wasting away. The ashes of the feathers when devoured relieve the gallic sickness, acting in a wonderful manner.

"The bird lives in warm regions, such as Yauhtepeceusis, generally establishing itself in trees growing along the banks of the streams, where we, having observed it, captured it, and making a drawing of it, kept it alive."

This description is said by Mr. C. William Beebe, the greatest living authority upon the subject, to be fairly accurate, except, of course, as regards the medieval medical ideas and the statement that the bird's food consists of snakes.

Food.—As a matter of fact the bird is vegetarian in habit and its food consists almost entirely of two or three species of marsh plants; one of these is the mucka-mucka or arum (*Montrichardia ardorescens*) a tall plant with large heart-shaped leaves and a fruit resembling a pineapple. The bird feeds upon the leaves, flowers and fruit. The food also includes the tough leaves of the white mangrove and several varieties of wild fruit, including the sour guava.

GENERAL CHARACTERISTICS

While the hoatzin strongly resembles a pheasant in general appearance, it also reminds one of a peacock, especially as regards the bearing of the neck and head, as well as in the graceful crest. The bird has a short, strong beak of peculiar shape, well adapted to deal with the sturdy vegetation upon which it feeds. Its total length is about twenty-three inches, the wing 12½ inches long, the tail 12, the tarsus 2, and the middle toe and claw 3. The plumage of the body is very loose; the wings and tail are large as compared to the body and are furnished with strong well knit feathers, a rather surprising fact since the bird has a very weak flight. When sitting quietly, either perching or on its nest it is extremely hard to discern, because of its admirable protective color, but when it takes flight it at once becomes extremely conspicuous.

Peculiar Features.—The most strikingly peculiar features of the hoatzin, however, consist in its unique structure, a survival of a prehistoric age, in its singular crop, and in its offensive odor.

The scientific name of the bird is *Opisthocomus hoazin*, and it is such an extremely ancient and entirely isolated type, that it has been set aside in a separate order by itself—the order of *Opisthocomiformes.* It possesses a vestigial claw on the third digit which links it with the primitive *Archaeopteryx.*

YOUNG HOATZIN CLIMBING A TREE WITH THE AID OF CLAWS ON ITS WINGS

Another claim which it possesses to be regarded as a primitive form consists in the fact that the young birds behave like quadrupeds, whence our title of four-legged birds. They have unusually well-developed forelimbs and "fingers" and possess external claws on the first and second finger, which they make use of in climbing vigorously about the bushes which surround the nest. This habit is strikingly described by an American naturalist, Mr. Edward Brigham, who observed it

while making a collection of the embryos of vertebrates in the Island of Marajo at the mouth of the Amazon. He noticed that shortly before the egg was hatched two complete toes appeared at the ends of the forelimbs (wings) which suggested to him the probability that they were intended for some special service. Shortly afterward he had the pleasure of finding that his surmise was correct. He writes:

"One day in June while rowing upon the lower waters of the Rio Negro, the natives pushed our boat into the edge of an *igapo* or submerged forest. The water was visible between the tops of the trees. Evil-looking alligators snorted, barked, and roared as they glided among the half-submerged tree tops. Enormous iguanas sunning themselves upon the highest branches from three to six yards above our heads in unusual numbers, dived suddenly head first in the igapo. Never before had I been witness to so interesting a scene of reptile life. My curiosity was increased by the presence of the hoatzins, who were screeching and quarreling around me. I was particularly interested in the demonstration before me since I had been engaged in studying the vestiges of a reptile origin found in the anatomy of these birds. I had a distinct impression, in fact, that I was somehow engaged in watching a scene in the Mesozoan age. Buried in these thoughts my attention was suddenly attracted toward the lowest branches of the trees by a plunge which appeared to be different from that of the iguanas, as if some other kind of animal had slid into the water. Very close to this point I then caught sight of a young hoatzin sitting upon a low branch. The Indians told me that the noise I had heard had been made by a young cigana diving into the water. I ordered them to catch the other one which we saw, but it likewise dived and disappeared. Shortly afterward, however, we saw the first bird emerge from the water and climb up a submerged branch on *all fours*. An Indian killed the bird and I prepared its skin, at the same time pointing out to my men the *anterior claws*. They seemed astonished by the sight but after some reflection an old man said: 'The young siganos climb out of the water with those feet there.' The presence of the toes upon the wings made clear to him the explanation of the phenomenon with which he was familiar but which had always remaind a mystery to him."

Mr. Brigham ascribed the feeble powers of flight of the bird noted above to this habit of climbing like a quadruped during a long period of development. It should be noted, further, that the sternum or the breast bone has no "keel" and, consequently, it appears to be impossible for the young bird to get out of the water except by means of climbing, but since they do not possess webbed feet their wings are more useful in escaping enemies than is their ability to dive.

The Crop.—This reduction of the front part of the keel of the sternum is a condition which is absolutely unique among birds, and it is a direct result of the peculiar character of the crop. This organ has, in fact, assumed the structure and importance belonging to the gizzard in other birds. Its walls are thick and muscular instead of being flabby and glandular, and it has increased in size very greatly, measuring about 2½ inches in diameter when extended with food.

The Foetid Odor.—Various conflicting statements are made as to the nature of the unpleasant odor emanating from the flesh of the hoatzin and its cause. It is sometimes said to be so frightful that it is only possible to skin the birds under water. Some authorities ascribe it to the aroid shrub upon which it feeds. It is variously described as reminding one of a strong cow shed and as resembling a mingling of musk with wet cattle hides, but Dr. Beebe has the following to say, regarding this point, in a report made to New York Zoological Society.

"On our Venezuelan trip we were warned again and again concerning the frightful odor supposed to characterize these birds. Some said they would have to be skinned under water! We found this wholly false. When skinning or dissecting one of these hoatzins one notices the faintest of musky odors, not at all unpleasant, and indeed perceptible only when the attention is directed to it. Our specimens were certainly most inoffensive in this respect, and the flesh of one which we cooked and ate, while it was tough, was as clean and appetizing as that of a curassow.

"In British Guiana the above experience was repeated, although the 'stinking pheasant' was held in horror by the blacks. But as before, we could detect nothing but a slightly musky odor. The odor is exceedingly persistent and is given off by skins which are several years old. Its cause is problematical and the direct connection with the crop is very doubtful. There is little doubt but that hoatzins differ greatly, either seasonably or individually, in regard to the intensity of this odor. Far be it from me, however, to emphasize any lack of it, for the very thread of existence of this most interesting bird hangs upon belief in this inedibility."

MATING HABITS

The hoatzin is monogamous and both sexes assist in building the nests which are woven of twigs and sometimes placed in a crotch of a tree or more rarely supported by several branched mucka-mucka stems. There are usually two eggs in the nest though sometimes three or four are found. They are variable in shape, being sometimes elliptical and sometimes oval. The size averages 1.8 by 1.3 inches. The ground color is creamy white. The entire surface is marked with small, irregularly shaped dots and spots of reddish brown, inclining to be more abundant at the large end. The brown pigment deposited early in the oviduct is covered by a thin layer of lime and thereby given a lavender hue.

NEW STUDIES AT THE TROPICAL RESEARCH STATION

In 1916 Dr. Beebe took charge of the Tropical Research Station established in British Guiana, under the auspices of the New York Zoological Society, together with two assistants and two artists, the enterprise being made possible by the generosity of a group of well-known New Yorkers. During the period of residence from March to August, Dr. Beebe was able to extend his observations concerning this strange and interesting bird which he terms "a reptile-like living fossil." In his report of the trip published is 1917, he gives the following entertaining account of the quaint nestlings and their solicitous parents:

"The nestlings in seven occupied nests observed as we drifted along shore or landed and climbed among the thorns, were in an almost identical stage of development . . . their down was a thin, scanty, fuzzy covering, and the flight feathers were less than a half inch in length. No age would have showed to better advantage every movement of wings or head.

"When a mother hoatzin took reluctant flight from her nest, the young bird at once stood upright and looked curiously in every direction. No slacker he, crouching flat or waiting his mother's directing cry. From the moment he was left alone he began to depend upon the warnings and signs which his great beady eyes and skinny ears conveyed to him . . . but one little hoatzin failed to count on the invariable exception to every rule, for this day the total unexpected happened, and fate, in the shape of enthusiastic scientists, descended upon him. He was not for a second disconcerted . . . and we found him no mean antagonist and far from reptilian in his ability to meet new and unforeseen conditions.

"His mother, who a moment before, had been packing his capacious little crop with predigested pimpler leaves, had now flown off to an adjoining group of mangroves, where she and his father croaked hoarse encouragement. His flight feathers hardly reached beyond his finger tips and his body was covered with a sparse coating of sooty black down. So there could be no resort to flight. He must defend himself, bound to earth like his assailants.

"Hardly had his mother left when his comical head, with thick, blunt beak and large intelligent eyes, appeared over the rim of the nest. His alert expression was increased by the suspicion of a crest on his crown, where the down was slightly longer. Higher and higher rose his head, supported on a neck of extraordinary length and thinness. No more than

this was needed to mark his absurd resemblance to some strange, extinct reptile. A young dinosaur must have looked much like this, while all that my glance revealed, I might have been looking at a diminutive Galapagos tortoise. Indeed this simile came to mind often when I became more intimate with nestling hoatzins. Sam, my black tree climber, kicked off his shoes and began creeping along the horizontal limbs of the pimplers. At each step he felt carefully with each calloused sole in order to avoid the longer of the cruel thorns, and punctuated every yard with some gasp of pain or muttered personal prayer, 'please, don' stick me, thorns!' At last his hand touched the branch, and it shook slightly. The young bird stretched his mittened hands high above his head and waved them a moment. With similar intent a boxer or wrestler flexes his muscles and bends his body. One or two uncertain forward steps brought the bird to the edge of the nest and at the base of a small branch. There he stood and raising one wing leaned heavily against the stem, bracing himself. My man climbed higher and the nest swayed violently. Now the brave little hoatzin reached up to some tiny side twigs and aided by the projecting ends of dead sticks from the nest, he climbed with facility, his thumbs and forefingers apparently being of more aid than his feet. It was fascinating to see him ascend, stopping now and then to crane his head and neck far out, turtle-wise. He met every difficulty with some new contortion of body or limbs, often with so quick or so subtle a shifting as to escape my scrutiny. Once he even chinned himself. The branch ended in a tiny crotch and here, perforce, ended his attempt at escape by climbing. He stood on the swaying twig, one wing clutched tight and braced with both feet. Nearer and nearer crept Sam. Not a quiver on the part of the little hoatzin. We did not know it, but inside that ridiculous head there was definite decision as to a deadline. He watched the approach of this great strange creature, this danger, this thing so wholly new and foreign to his experience and doubtless to all the generations of his forebears. A black hand grasped the thorny branch six feet from his perch, and like a flash he played his next trick—the only remaining one he knew, one that set him as apart from all modern land birds as is the frog from the swallow.

"The young hoatzin stood erect for an instant, and then both wings of the little bird were stretched straight back, not folded, bird-wise, but dangling loosely and reaching well beyond the body. For a considerable fraction of time he leaned forward. Then without effort, without apparent leap or jump he dived straight downward, as beautiful as a seal, direct as a plummet and very swiftly. There was a scarcely noticeable splash and as I gazed with real awe, I watched the widening ripples which undulated over the muddy water, the only trace of the whereabouts of the young bird.

"It seemed as if no one, whether ornithologist, evolutionist, poet, or philosopher could have failed to be profoundly impressed at the sight we had seen. Here I was in a very real, a very modern boat, with the honk of motor horns sounding from the river road a few yards away through the bushes, in the shade of this tropical vegetation in the year nineteen hundred and sixteen, and yet the curtain of the past had been lifted, and I had been permitted a glimpse of what must have been common in the millions of years ago. It was a tremendous thing, a wonderful thing to have seen and it seemed to dwarf all the strange sights I had seen in all other parts of the earth's wilderness. I had read of these habits and had expected them, but like one's first sight of a volcano in eruption, no reading or description prepares one for the actual phenomenon.

"I sat silently watching for the reappearance of the young bird. We tallied five pairs of eyes and yet many minutes passed before I saw the same little head and emaciated neck sticking out of the water alongside a bit of drift rubbish. The only other visible thing was the protruding spikes of the bedraggled tail feathers. I worked the boat in toward the bird, half-heartedly, for I had made up my mind that this brave little bit of atavism deserved his freedom, so splendidly had he fought for it among the pimplers. Soon he ducked forward, dived out of sight and came up twenty feet away among an inextricable tangle of vines. I sent a little cheer of well wishing after him and we salvaged Sam.

"Then we shoved out the boat and watched from a distance. Five or six minutes passed and a skinny, crooked two-fingered mitten of an arm reared upward out of the muddy flood and the nestling, black and glistening hauled itself out of the water. Thus must the first amphibian have climbed out, shaken the water from its eyes and gasped in the thin air. But the young hoatzin neither gasped nor shivered, and seemed as self-possessed as if this were a common occurrence in its life. There was not the slightest doubt, however, that this was its first introduction to water. Yet it had dived from a height of fifteen feet, about fifty times its own length, as cleanly as a seal leaps from a berg. It was as if a child should dive two hundred feet!

"In fifteen minutes more it had climbed high above the water and with unerring accuracy directly toward its natal bundle of sticks overhead. The mother now came close and with hoarse, rasping notes and frantic heaves of tail and wings lent encouragement. Just before we paddled from sight, when the little fellow had reached his last rung, he partly opened his beak and gave a little falsetto cry—a clear, high tone, tailing off to a guttural rasp. His splendid courage had broken at last; he had nearly reached the nest and he was aching to put aside all this terrible responsibility, this pitting of his tiny might against such fearful odds. He wanted to be a helpless nestling again, to crouch on the springy bed of twigs with a feather coverlet over him and be stuffed at will with delectable pimpler pap. Such is the normal destiny of a hoatzin chick and the wheee-og! wrung from him by the reaction of safety, seemed to voice all this."

A curious circumstance is that the wing claws molt; in the nestling of a fortnight they are sharp and curved like those of a cat. But the claws on both thumb and forefinger are shed at least twice in the first four months.

In feeding, the nestling cranes its neck upward and thrusts its head well down the mother's throat for from 10 to 20 seconds.

They swim well, using the feet alone, but are extremely clumsy on the ground—"as helpless as seals"—pulling themselves clumsily along by the wing claws while the feet kick out behind in a futile manner.

CURIOUS FACTS ABOUT THE CUCKOO'S EGG

Just as the cuckoo is one of the most baffling of birds to the ornithologist, so its egg presents suprising peculiarities. While birds' eggs possess a uniform and distinctive character as to their color and markings, that of the cuckoo commonly exhibits a likeness to those of the involuntary foster parents. Thus we find white, green and blue cuckoos' eggs; some with only a few speckles, while others are elaborately variegated.

This mimicry was the subject of an address by Lieut. von Lucanus before the German Ornithological Society in Berlin. He stated that of 765 cuckoo eggs in the Berlin Natural History Museum 575 strikingly resembled the eggs of the foster parent in color and marking; 169 were entirely unlike those of the deceived bird, and 120 of those had been laid in the wren's nest. Of the first lot 502 were in the nest of the warbler or hedge sparrow. The eggs of the garden warbler vary considerably in color and marking, which favors the deception by the cuckoo.

Other instances in which the hostess' egg closely resembles the invader's include the gray fly catcher, the white wagtail, and the Asiatic yellow hammer. In the latter case the resemblance is really remarkable, since the egg of this bird is peculiarly characteristic, being of a white ground with dark brown twisted scrawls and vermiform lines forming a wreath about the big end of the egg! Who will solve this riddle? asks the *Naturwissenschaftliche Umschau* (Berlin), for April, 1920.

Flower-Like Fauna of the Sea

Sea Anemones, Jelly Fish and Other Members of the Coelenterata

By T. A. Marchmay

Illustrated with photographs of models in the American Museum of Natural History

THE creed of the systematic is to have a place for everything and everything in its place, a slogan which some ingenious not to say disorderly person has neatly twisted into "have a place for everything and put everything in that place." This suggests the difference between the structure of the vertebrates and that of the large family or *phylum* known as the *Coelenterata*. In the former the various functions involved in the process of life, nutrition, elimination, circulation, respiration, and reproduction are assigned to separate organs of definite location and highly complex nature as well as greatly differentiated in character. In the *Coelenterata*, on the other hand, all these functions are carried on in a single organ, the bag-like body or *Coelenteron* of the animal.

This coelenteron is from one point of view as simple in structure as a lady's reticule, since it consists mainly of two layers of cells like the material and the lining of the reticule. These inner and outer layers are divided, however, by a stratum of a jelly-like substance, which is sometimes quite thick and sometimes very thin.

The external shape of these creatures is extremely various and curious in spite of the simplicity of the main portion of the body. This variety of form is due to the fact that the appendages of the body are radiating in character. While they are quite symmetrical it is not a bilateral symmetry such as vertebrates possess, but a *radial* symmetry.

AN UMBRELLA-LIKE HYDROZOAN

THE PORTUGUESE MAN-OF-WAR

This radial symmetry has been acquired and has no further significance than the adaptation of different animals to somewhat similar conditions of life. It is not only in the animals formerly classed by Cuvier as Radiata, but in sedentary worms, Polyzoa, Brachiopoda, and even Cephalopoda among the mollusca, that we find a radial arrangement of some of the organs. It is interesting in this connection to note that the word "polyp" so frequently applied to the individual coelenterate animal or zooid, was orignally introduced because of a fancied resemblance of a *Hydra* to a small cuttlefish (*Fr.* Poulpe, *Lat.* Polypus).

The body of the coelenterate, then, consists of a body-wall enclosing a single cavity ("coelenteron"). The body-wall consists of an inner and an outer layer of cells, originally called by Allman the "endoderm" and "ectoderm" respectively. Between the two layers there is a substance chemically allied to mucin and usually of a jelly-like consistency, for which the convenient term "mesogloea," introduced by G. C. Bourne, is used.

The mesogloea may be very thin and inconspicuous, as it is in *Hydra* and many other sedentary forms, or it may become very thick, as in the jelly fishes and some of the sedentary *Alcyonaria*. When it is very thick it is penetrated by wandering isolated cells from the ectoderm or endoderm, by strings of cells or by cell-lined canals; but even when it is cellular it must not be confounded with the third germinal layer or mesoblast which characterizes the higher groups of animals, from which it differs essentially in origin and other characters. The Coelenterata are two-layered animals (*Diploblastica*), in contrast to the Metazoa with their three layers of cells (*Triploblastica*). The growth of the mesogloea in many Coelenterata leads to modifications of the shape of the coelenteric cavity in various directions. In the Anthozoa, for example, the growth of vertical bands of mesogloea covered by endoderm divides the peripheral parts of the cavity into a series of intermesenterial compartments in open communication with the axial part of the cavity; and in the jelly fishes the growth of the mesogloea reduces the cavity of the outer regions of the disk to a series of vessel-like canals.

Another character of great importance possessed by all Coelenterata is the "nematocyst" or "thread-cell." This is an organ produced within the body of a cell called the "cnidoblast," and it consists of a vesicular wall or capsule, surrounding a cavity filled with fluid containing a long and usually spirally coiled thread continuous with the wall of the vesicle. When the nematocyst is fully developed and receives a stimulus of a certain character, the thread is shot out with great velocity and causes a sting on any part of an animal that is sufficiently delicate to be wounded by it. It resembles, in short, a minute harpoon.

The morphology and physiology of the nematocysts are very complex. By some authorities it is supposed that the cnidoblast is a highly modified form of mucous or gland cell, and that the discharge of the nematocyst is subject to the control of a primitive nervous system that is continuous through the body of the zooid.

The Coelenterata are divided into four classes:

1. *Hydrozoa.*—Without stomedacum (*i.e.*, the anterior part of alimentary canal) and mesenteries. Sexual cells discharged directly to the exterior.

2. *Scyphozoa.*—Without stomedacum and mesenteries. Sexual cells discharged into the coelenteric cavity.

3. *Anthozoa-Actinozoa.*—With stomedacum and mesenteries. Sexual cells discharged into the coelenteric cavity.

4. *Ctenophora*, including comb-jellies.

The full meaning of the brief statements concerning the structure of the classes given above cannot be explained until the general anatomy of the classes has been described. It may be stated, however, in this place that many authors believe that structures corresponding with the stomedacum and mesenteries of Anthozoa do occur in the Scyphozoa, which they therefore include in the class Anthozoa.

Among the more familiar animals included in the class

of Hydrozoa may be mentioned the fresh-water polyp *Hydra*, the *Hydroid* zoophytes, many of the smaller Medusae or jelly-fish, the Portuguese Man-of-War (Physalia), and a few of the corals.

Included in the Scyphozoa are the large jelly-fish found floating on the sea or cast up on the beach on shores.

The Anthozoa include the sea-anemones, nearly all the stony corals, the sea-fans, the black corals, the dead-men's fingers (Alcyonium), the sea-fans, and the precious coral of commerce.

These classes are based upon the arrangement of the eggs. The number of divisions formed by the radiating partitions mentioned above vary with the different species and also according to age. Other partitions start from the outer sac and extend toward the central axis but do not unite with it. These partitions, which are known as *mesenteries* are always in definite multiples; they vary in different species, new divisions growing between the first partitions in regular order.

The Eggs.—The eggs of the animal are formed on the inner edge of the partitions and when they are ripe they drop into

BRYZOA OR MOSS ANIMALS
They are of compound structure with sheath-like envelope and circle of tentacles

the divisions or "chambers" mentioned above, and pass through openings in these into the central cavity or "stomach," whence they pass through the mouth into the water. These creatures are classified according to whether the eggs are formed on all or on special partitions; those in which there is a limitation and constancy of function are regarded as being of the highest order.

In all the coelenterates or polyps, as many of them are called, the mouth serves not only for the taking in of food and the expulsion of the eggs, but also for the elimination of the waste matter which results from the digestion and assimilation of the food and the replacing of worn tissues.

HYDROZOA

Among the hydrozoa there are two types in the form of the body. In some genera, such as the *Obelia*, there is a fixed branching colony of the animals, each of which is known as a zooid; these consist of a simple tubelike body composed of the two layers of cells referred to above, the ectoderm and the endoderm. This tube ends in a conical mound in the middle of which is the mouth which is surrounded by a ring of tentacles. This fixed colony increases in size much like a yeast plant does by the putting forth of buds, a process known as gemmation, since it produces no sex cell. But at a certain season of the year a number of the buds on the parent colony develop into small bell-shaped jelly fish, each of which is called a Medusa; these medusae swim away from the parent colony and enjoy a separate existence. Moreover, they proceed, when sufficiently mature, to develop sex cells. Thus we have an extremely interesting example of the always fascinating phenomenon known as the alteration of generations—a phenomenon generally supposed to be found in a somewhat limited number of plants and animals, but which certain recent investigators declare to be found in all forms of life from the highest to the lowest. (See Scientific American Monthly for May, 1921). The medusae are very graceful and pretty. The little creature is like a delicate fairy bell in shape and its mouth is fringed with tentacles; there is even a sort of clapper to this dome-shaped and contractile bell, consisting of a tube extending from the center and having the mouth at its lower end. Sometimes these tentacles are solid and sometimes they are hollow, containing a cavity connected with the main cavity in the body.

In the Medusa stage the hydra is naturally more complicated in structure so as to adapt it to the more varied conditions of life found by a free-swimming creature. The bell of the Medusa or the "umbrella" as it is sometimes called, is perforated by small radiating tubes or canals. Along the margin of the umbrella or at the base of the tentacles are found certain opaque red or blue spots, called ocelli and supposed to be sense organs. Other spots similarly located are known as statocysts.

A specially interesting genus is the *hydra* which is one of the few examples among the coelenterates which is found exclusively in fresh water; it is very widely distributed, being found not only in Europe and North America, but in New Zealand, Australia and the tropical portions of Central Africa and Central America. In temperate zones it is commonly found in clear, still, fresh water, attached to the stems or leaves of water plants. When fully extended its tubular body may be as much as 25 mm. in length, but in a completely retracted state the same individual will be only about ⅛ as long. During most of the summer the colony increases by gemmation. The young hydra so produced themselves produce buds, but usually not until after they have left the parent.

The reproductive process of this animal is peculiar in that the individuals may be either male, female, or double-sexed, and the condition appears to depend upon the relative abundance of the food supply. According to a well-known German naturalist when hydras have been well fed most of them become females; when the food supply has been greatly restricted the majority become males, and when the food supply is moderate in amount the majority become double-sexed. The gonads are simply clusters of sex cells situated in the ectoderm. There is no evidence either in their structure or their development to show that they represent reduced medusi form gonophones. The testis produces a number of minute spermatozoa. In the ovary, however, only one large yolk-laden egg-cell reaches maturity by the absorption of the other eggs. The ovum is fertilized while still within the gonad, and undergoes the early stages of its development in that position. With the differentiation of an outer layer of cells a chitinous protecting membrane is formed, and the escape from the parent takes place. It seems probable that at this stage, namely, that of a protected embryo there is often a prolonged period of rest, during which it may be carried by wind and other agencies for long distances without injury. (Vide Cambridge Royal Nat. History).

The remarkable power that the hydra possesses of recovery from injury and of regenerating lost parts was first pointed out by Trembley in his classical memoir.

A *Hydra* can be cut into a considerable number of pieces, and each piece, provided both ectoderm and endoderm are represented in it, will give rise by growth and regeneration to a complete zooid. There is, however, a limit of size below which

fragments of *Hydra* will not regenerate, even if they contain cells of both layers. The statement made by Trembley, that when a *Hydra* is turned inside out it will continue to live in the introverted condition has not been confirmed, and it seems probable that after the experiment has been made the polyp

SEA ANEMONES—A NEW ENGLAND ACTINIA
The stomach at the center is surrounded by tentacles which capture its food

remains in a paralyzed condition for some time, and later reverts, somewhat suddenly, to the normal condition by a reversal of the process. There is certainly no substantial reason to believe that under any circumstances the ectoderm can undertake the function of the endoderm, or the endoderm the functions of the ectoderm so far as has been observed.

One of the characteristic features of *Hydra* is the slightly expanded disk-shaped extremity opposite the mouth usually called the "foot," though "sucker" would be a better term. There are no root-like tendrils or processes for attachment to the support such as are found in most of the solitary Gymnoblastea. The attachment of the body to the stem or weed or surface-film or other point of support by this sucker enables the animal to change its position at will. It may either travel slowly by sliding along its support without using the tentacles as do many sea-anemones, or more rapidly by a series of somersaults, as originally described by Trembley. The latter mode of locomotion has been recently described as follows: "The body, expanded and with expanded tentacles, bends over to one side. As soon as the tentacles touch the bottom they attach themselves and contract. Now one of two things happens: the foot may loosen its hold on the bottom and the body may contract. In this manner the animal comes to stand on its tentacles with the foot pointing upward. The body now bends over again until the foot attaches itself close to the attached tentacles. These loosen in their turn, and so the *Hydra* is again in its normal position. In the other case the foot is not detached, but glides along the support until it stands close to the tentacles which now loosen their hold."

The *Hydra* appears to be purely carnivorous. It will seize and swallow *Entomostraca* of relatively great size so that the body-wall bulges to more than twice its normal diameter. But smaller crustacea, anolid worms and pieces of flesh are readily seized and swallowed by a hungry hydra.

While, as we have said, it is a characteristic feature of all the coelenterates to possess stinging organs, that of the hydra is especially worth describing because of the availability of this wide-spread little animal for study, even by amateurs. In a delightful book, recently published, *Aquatic Microscopy for Beginners*, by Alfred C. Stokes, this sting and the hydra's manner of using are thus entertainingly described:

"The food consists of small worms, water fleas, etc., or even of little pieces of raw beef if the observer chooses to feed them to the hydra. They seize the living victim as it is swimming by and twining a tentacle around it, draw the struggling creature to the mouth through which it is thrust into the stomach. The act of seizure takes place so rapidly that the eye can seldom follow it. The observer can usually know that the prey is caught only by seeing it slowly approaching the oral aperture. Often, when the captured object is too large or strong for one arm to hold several tentacles bend over and twine around it. A creature once caught rarely escapes.

"The writer has amused himself, and doubtless pleased the hydra, by feeding them with small larvæ or with aquatic worms. Take in the forceps a small aquatic worm by one end, and present the wriggling thing to a hydra's arm. No second invitation is needed. The worm is quickly embraced. If too long to be swallowed all at once part of it will hang out of the mouth until the other end is digested; the tentacles in the meanwhile will not cease to fish for more.

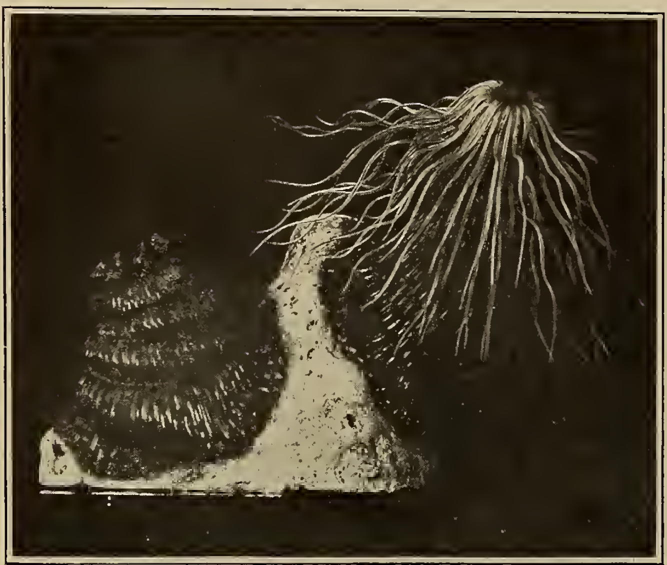
"The body and tentacles of the *Hydra vividis* are roughened by little elevations or warty prominences. The brown species is not so much roughened. These protuberances contain what are called the stings, small, oval, or vase-shaped hollow bodies, with a fine thread coiled in the interior, and four minute spines near the summit. When the hydra is irritated by the pressure of the cover-glass these stings are thrown out violently, and the long stiff thread can be well seen; when in the animal's body they cannot be so easily examined. They are often found on the side when no hydra is to be seen. They are sometimes noticeable sticking in the body of some worm or larva that has escaped a fatal embrace. The writer has more than once found a *Chironomus* larva in a dying condi-

TIDAL POOL AT NAHANT, MASS., UNUSUALLY RICH IN SEA ANEMONES AND OTHER PICTURESQUE GROWTHS

tion and ornamented by a spiral band of these stings in its skin. It had evidently had a tussle with a hydra and escaped."

The Millepores.—The Hydrozoa also include the millepores, which are colonies of zooids or zoophytes (*i.e.*, animal plants),

to use the older term, which secrete a stony skeleton instead of a horny one; they resemble in this respect the true corals but differ from them in other ways so as to come under a different class. The essential difference between the genus *Millepora* (literally a thousand pores) and the true corals is that in the former the different members of the colony have different functions to perform for the common welfare of the community, while in the true corals, which are likewise



CLADACTUS COSTA—A SEA ANEMONE WITH GRACEFUL THREAD-LIKE TENTACLES

grouped in communities, each member is a complete individual. Another marked difference is in the arrangement of the stony partitions, which in the millepores are the outside covering and connecting canals, while in true corals they are vertical partitions inside the animal between the inner and outer sacs. One of the most beautiful of these millepores is *M. alcicornis* or elk-horn coral which is found abundantly in Florida, and has helped to build the reefs off the coast of that state.

We must not leave the subject of the Hydrozoa without mentioning that many of their colonies resemble seaweed while others are like tufts of moss, fronded leaves or even feathers. Common along the coast of New Jersey and northward are the *Sertularia argentia* whose colonies are often more than a foot long with thickly growing silvery branches on a darker stem, and the *S. cupressina* or sea cypress. One of the most beautiful of all hydroids resembles an ostrich plume. Its scientific name is *Aglaophemia struthioides.*

Another hydroid famous for its ethereal delicacy and beauty is the Portuguese Man-of-War, which is one of the most remarkable examples of an animal community in all nature. This member of the hydrozoa belongs to the order Siphonophora and the genus Physalia, while its proper name is *P. arethusa.* As our illustration shows the most prominent part of the compound body is the pear-shaped bag called the float; this rests upon the surface of the water and is filled with air. This delicate structure presents exquisite changing tints of rose and azure, so that it is like a huge sweet pea blossom drifting upon the water. It is, however, about the size of a large pear. Along its top is a crest which takes the wind like a sail, while long tentacles or streamers hang down into the water, being massed near the broader end of the float. The longest of these tentacles are on the outside and serve to keep the crest or sail spread before the wind; when the latter is very strong they extend themselves to a really remarkable length—from 40 to 50 feet; they thus act as anchors to keep the colony from being driven toward the shore. Furthermore, they act as steering apparatus changing the course of the colony by raising the pointed end of the float and thus forcing it to come about.

Some of these tentacles are covered with stinging cells or cells as they are picturesquely called; these obviously represent the military class of the community; some are the feeding zooids who have charge of the commissary department, as we may say. These zooids whose function it is to absorb nutriment for the community have flask-shaped bodies, others look like clusters of grapes and it is the function of these to perpetuate the species.

The second division of Coelenterates, the *Scyphozoa*, are almost all when full grown, of Medusa type, and for this reason they are sometimes known as scyphomedusæ; they are jelly fishes and are usually found floating on or near the surface of the sea. While some species are only an inch or two in diameter, others are very large, including, indeed, the largest individual zooids found among the coelenterates. Some of these have a disk or umbrella 3 or 4 feet or even 7 feet or more in diameter and a specimen obtained in the Antarctic Expedition of 1898-1900 weighed no less than 90 pounds. The color is very variable and beautiful and it is this together with the graceful form and the floating fringe of tentacles which makes one instinctively compare them with flowers. A soft milky blue or opalescent tint is the most general, but many species show shades of green, blue, brown and purple. The tissues of these medusæ are, in general, less transparent than in the medusa form of the hydrozoa described above. The deep sea species are, generally, dark red or opaque brown in color. While the color is generally uniformly distributed, sometimes it occurs in irregular brown or yellow patches like freckles. Sometimes brighter spots of color appear on the tips of the tentacles and the lips of the mouth, and it is thought by some naturalists that these brighter tints may act as a bait in attracting small fish and crustaceans.

Some of the Scyphozoa are phosphorescent and it is these which form the lines of white fire seen along breaking waves at night. The writer remembers well that upon coming out of the water after a dip in the ocean at night, in the surf off the east coast of Florida, one's bathing suit was gemmed with bits of pale white fire, from the small phosphorescent jelly fish clinging to it. Among the most brilliant and conspicuous of all phosphorescent creatures, indeed, are the *Pelagia noctiluca* and *P. phosphora* and their unearthly blue radiance can often be recognized from the deck of a ship in mid ocean.

The umbrella varies a good deal in shape, being usually flattened and disk like, but sometimes conical, cubical or almost globular.

The large jelly fishes usually have a shape not unlike that of a mushroom. In some species there is a horizontal mem-

SPECIMEN OF NUDIBRANCH—SO CALLED FROM THE NAKED GILLS ON BACK AND SIDES

brane called the velum or veil, extending around the inner circumference of the disk.

In some species of these large jelly fish the stinging cells are so powerful that they have been compared with an electric battery. When the nettle-like threads contained in the poison cells succeed in penetrating the flesh of a man they are said to produce a sensation like that from an electric shock; the jelly fish employs this weapon to benumb its prey. It is even believed that some deaths by drowning have been caused by

a swimmer coming in contact with one of these big jelly fish and being paralyzed by the shock received.

The Rhizostomæ.—Among the most peculiar of the jelly fishes are those belonging to the sub order *rhizostomæ* (literally root-mouthed). These have no tentacles, but covering the end of the simple organ or manubrium are certain oval appendages provided with numerous funnel-shaped orifices called suctorial mouths. This plurality of mouths is stated to be unique in the animal kingdom. The different species vary in diameter from 3 to 8 inches. A typical member of the group is the genus Cassiopeia; the accompanying illustration shows the *C. frondosa.* On the margin of its circular disk there are no tentacles, but there are 16 sense organs called tentaculosysts. The lower end of the manubrium (the central tube ending in the mouth), which in other jelly fishes is merely an open mouth, is closed by 8 arms which spring from it; these are much branched and the branches in turn have numerous appendages, some of which look like little polyps, and which have mouths surrounded by crowns of tentacles. While this jelly fish is able to swim freely it usually lies upon its back lazily spreading and closing its disk without changing its position whie its arms extending upward make it look like a bit of seaweed.

THE ANTHOZOA

While the third class of the coelenterates, the anthozoa or actino zoa includes the stony corals, the flexible corals and precious coral, we shall here confine ourselves chiefly to the other members of the class, the sea anemones and the sea pens.

The animals of this class are divided into sub classes from differences in their anatomy. In the first, which includes the sea-anemones and the reef-building corals, the polyps have numerous simple hollow tentacles and the same number of raidal partitions, both being some multiple of six. Since this multiple of six is found in the arrangement of many flowers it suggests one reason for the resemblance of these fauna to many of our most attractive flora. The polyps of a colony are all alike and they all secrete carbonate of lime.

The Alcyonaria, or Halcyonoids.—In this second subdivision the tentacles and partitions are always eight in number, and the tentacles have small symmetrically-arranged branches. The hard secretions are horn and elastic, as in sea-fans, sea-whips, and sea-pens, or else extremely hard as in *Corallman rubrum.*

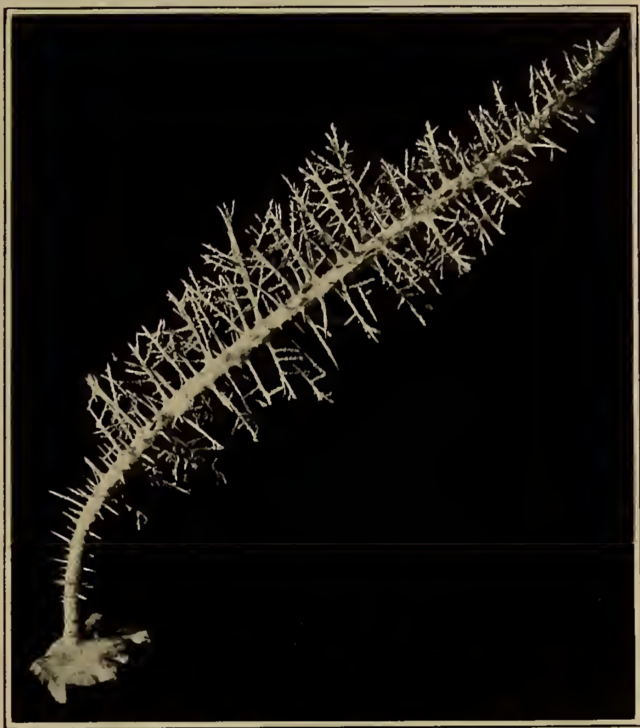
In the first class the sea-anemones belong to the order Actinaria in the subclass koantharia (literally *animal flowers*). Strange to say, while they strongly resemble flowers when expanded they do not resemble anemones. They vary greatly in color and form and are found in various parts of the globe, being largest and most brilliantly colored in tropical waters. Most of them are attached to some object but are able to change their location at will. Some of them, particularly the *Adamsia palliata* furnish an example of commensalism or symbiotic life. This sea anemone lives on the back of shells (generally whelk shells) which are inhabited by hermit crabs.

Corals.—The limits of this article prevent us from going fully into the subject of the corals, beyond saying that they resemble the sea anemone, being polyps constructed on the radial plan. They live in colonies, but unlike the hydroid colonies, each polyp is a complete organism and in the reef building corals all the individuals are alike.

Actinoid Corals.—In the alcyonaria or actinoid corals there are two kinds of polyps; the smaller have no tentacles and are called *siphono-zooids*, while the larger have only eight radial partitions and eight tentacles. Another characteristic of these polyps is the symmetrical arrangement of the branchlets on the tentacles. It is this arrangement which causes one of them to be known to fishermen as "dead men's fingers." Still another genus is the organ pipe coral or Tubipora which is a beautiful deep red in color and very frail, the many tubes of which it consists being slightly separated from one another but connected by horizontal platforms at short intervals. While the hard skeleton of the polyp is red the body of the animal itself is green, forming a striking contrast.

The sea-fans, sea-whips, sea-feathers present great variety of form and color. They grow in abundance on the coral reefs and mud flats of Florida, forming yellow-brown or purple masses resembling shrubbery.

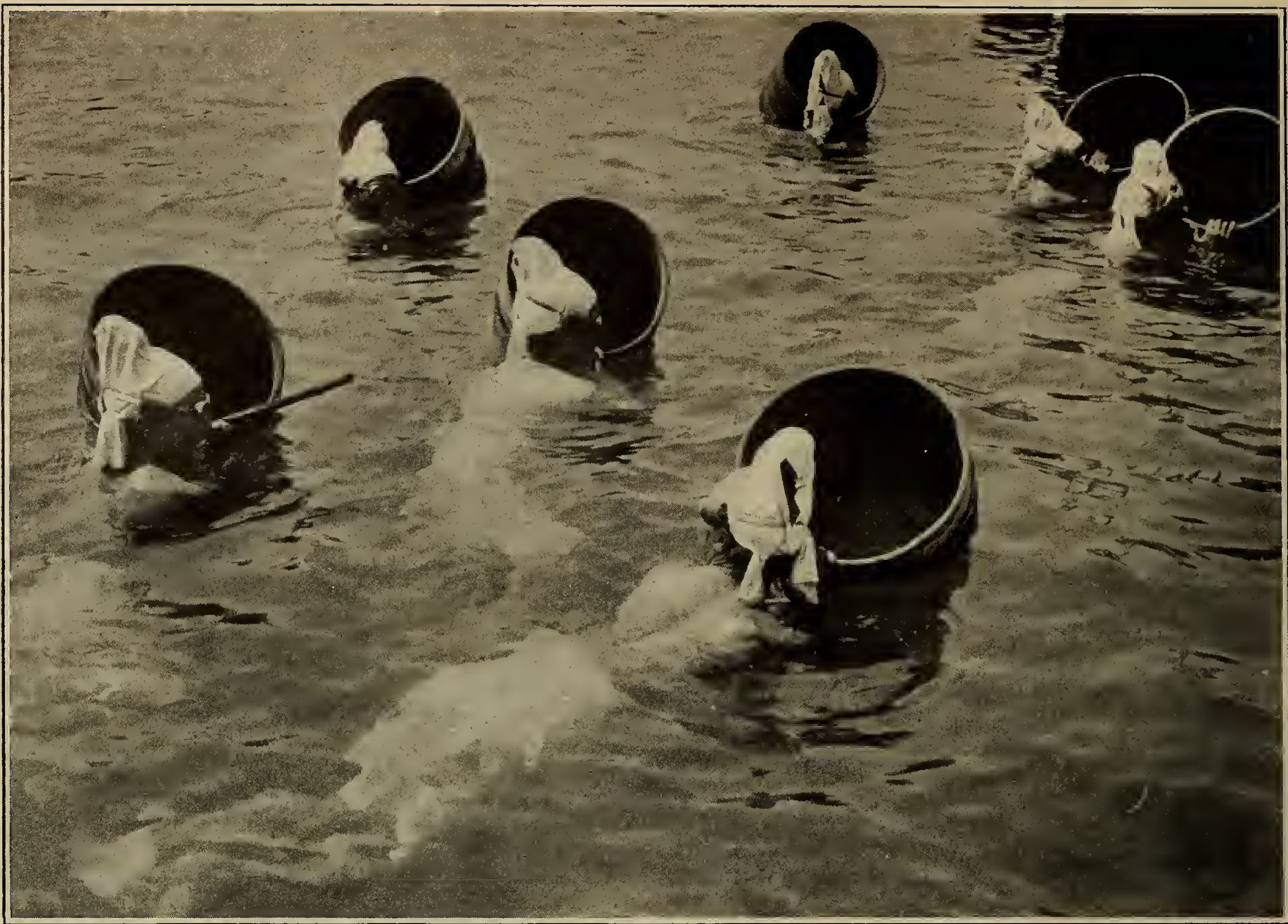
The Ctenophora.—These animals are known as comb jellies from the rows of flat cilia arranged like the teeth of a comb in 8 meridians, upon their spherical transparent bodies. The waving cilia give them a lovely prismatic shimmer by day, while at night they are phosphorescent. They differ from the jelly fish in their locomotion which is accomplished by means of the cilia. These operate like little paddles; they can be worked in unison, in single lines, or quite independently of each other, and for this reason the motion of the animal is very various and peculiar in character. A very curious feature in the comb jellies is the circulatory system through which they obtain both food and air; the mouth of the animal opens into a gullet which extends through ⅔ the length of the body.



NOT A SPRIG OF CEDAR BUT A LITTLE ANIMAL WITH A LONG NAME: *WALTERIA EUCKHARDI IJUMA*

On each side of the gullet is a vertical tube; these tubes unite at the base of the gullet and run from there as a single channel to the end opposite the mouth, opening to the outside through two excretory pores. From the base of the gullet where the tubes unite, two other tubes extend in a lateral direction; these divide and subdivide in a horizontal plane becoming eight in number; they connect at the surface with the lines of cilia and then divide and run in opposite directions to the two poles of the spherical body. At the pole opposite the mouth there is a nervous system located in a small area surrounded by cilia and having in its center an eye-speck or lithocyst.

Venus's Girdle.—Among the strangest of the comb jellies is the flat, narrow ribbon-like creature known as Venus's girdle, *Cestum veneris*, which is sometimes 4 or 5 feet long, though only an inch or two wide. The mouth is in the middle of the length, opposite the sense organ or eye spot. On each side of the mouth is a short tentacle. This animal moves more by means of contractions of its body than by the delicate combs which fringe its edges. It is very transparent, and of a delicate violet color. It is found in the Mediterranean Sea.



JAPANESE DIVING GIRLS AT WORK AT THE PEARL OYSTER BEDS

Artificially Induced Pearls*

A New Method of Producing Pearls Developed in Japan

By Dr. H. Lyster Jameson

ON May 4 a London evening paper announced that quantities of artificially produced Japanese pearls, of perfectly spherical shape, but containing in their centers heads of mother-of-pearl, had found their way into the London market and had deceived experienced pearl merchants in Hatton Garden, who had bought and resold them as naturally produced gems. Since that date many inaccurate, misleading, and contradictory announcements have appeared in the daily papers, leaving the public, both lay and scientific, in some confusion. The following statement of the position, so far as it can be judged from the scientific point of view, may therefore be useful:

For some years Mr. K. Mikimoto, the pioneer in the application of scientific knowledge to the pearly oyster on a commercial scale, has been producing in Japan, and selling under the name of "Mikimoto pearls," pearls of this description. There was no secret about this. Mr. Mikimoto not only sold them as artificially produced pearls, but also published in one of his catalogues (No. 33) a short description and diagram explaining his process.

Ever since 1898 Mr. Mikimoto (who began his work in collaboration with the late Prof. K. Mitsukuri in 1890) has been marketing half-pearls or "blisters," pearly excrescences formed by inserting a mother-of-pearl bead between the body of the oyster and the shell, and allowing the oyster to coat it over with nacre. This was, of course, merely a development of the very old operation by which the Chinese produce, in fresh-water mussels, the well-known mother-of-pearl images of Buddha, and of Linnæus's classical experiments in the eighteenth century. These products were known as "culture pearls," and have long been familiar in this country, set in brooches, tie-pins, rings, etc. Their value, compared with real pearls of corresponding sizes, was, of course, quite small.

For many years Mr. Mikimoto experimented with a view to the production of a complete pearl, not attached to the shell, by a modification of this process, and obtained his first successful results about 1912, as announced by me at the Dundee meeting of the British Association in that year. From information supplied to me by Mr. K. Ikeda, one of Mr. Mikimoto's staff, in a letter from Tokyo dated May 30, 1914, it appears that the first considerable crop of these "round cultivated pearls" was harvested in the autumn of 1913. Their production is now an important part of the original Japanese industry.

Apart from the purely financial question as to the degree to which the advent of artificially induced pearls is likely to affect the price of natural pearls, two questions seem to have been agitating the public: Are these products "pearls?" and can a test be devised by which, without destroying them, they can be distinguished from pearls of natural origin?

Of course, when a slice is cut across a natural pearl and a Mikimoto pearl the distinction is obvious. A natural pearl, except in those (in my experience exceptional) cases where a nucleus of foreign origin and of sufficient size to be identified

*From *Nature* (London), May 26, 1921, pp. 396-398.

(such as a grain of sand) is present, consists throughout of concentrically deposited layers, which differ in degree of transparency or opacity in different specimens (Fig. 1). The Mikimoto pearl, in its outer layers, has the same structure as the natural pearl, but has an artificially manufactured bead

FIG. 1. SECTION THROUGH THE CENTER OF A NATURAL PEARL, X 6½. (ORDINARY LIGHT.)

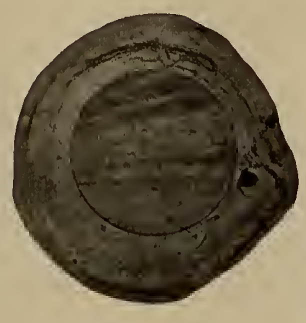


FIG. 2. SECTION THROUGH THE CENTER OF A MIKIMOTO PEARL, X 6½. (ORDINARY LIGHT.)

Preparation and photos by M. A. Brammall

of mother-of-pearl, composed of flat parallel laminæ of nacre, in its center (Fig. 2). (These preparations and photos were made under the supervision of Mr. Brammall, to whose investigations reference is made below.)

The method by which Mr. Mikimoto produces these pearls has been patented by him in Japan and other countries, and an application for a British patent has already been filed, and is open for inspection at the Patent Office. The information here given was obtained from this specification, from a short description and figure published in one of Mr. Mikimoto's catalogues, and from facts supplied by Mr. Toranosuke Kato, his London representative. The process involves the most delicate and skilful manipulation, and it could be carried out, presumably, only by carefully selected and trained workers. The shell is removed from one pearl oyster, and a bead of nacre or other suitable nucleus is laid on the outer shell-secreting epidermis of the mantle. This epidermis, which is

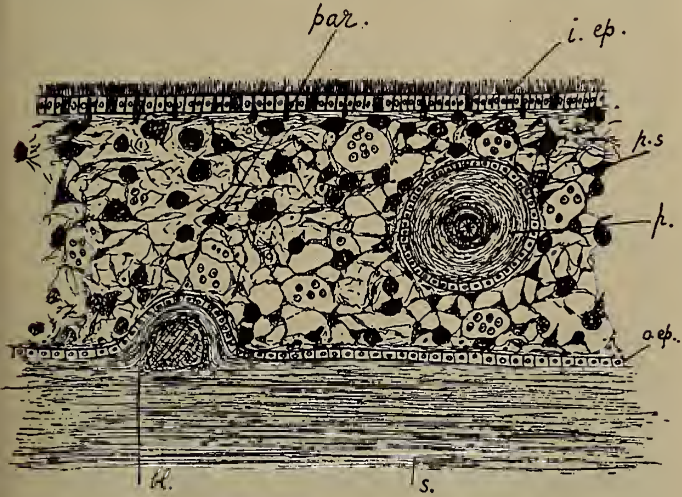


FIG. 3. DIAGRAM ILLUSTRATING THE DIFFERENCE BETWEEN A PEARL (*p.*) AND A BLISTER (*bl.*).

s., substance of shell; *o.ep.*, outer shell secreting epidermis; *p.s.*, pearl sac formed of shell-secreting epidermis; *i.ep.*, inner ciliated epidermis of mantle cavity; *par.*, parenchymatous connective tissue of mantle; *bl.*, blister; *p.*, pearl

composed of a single layer of cells of microscopic size, is then dissected off the oyster, and made to envelop the nucleus as a sac, the neck of which is ligatured. This sac is then transplanted into a second oyster and embedded in its sub-epidermal tissues, the ligature is removed, certain astringents or other reagents are applied to the wound, and the second oyster, with its grafted pearl sac containing the mother-of-pearl bead, is returned to the sea, where it has to remain for several years before a coating of pearl of sufficient thickness is secreted around the introduced bead. (In this letter of May 30, 1914, Mr. Ikeda stated that it took seven years.)

Now Mr. Mikimoto's success is based on the fact, which follows from my work in 1902,[1] and was further demonstrated by Alverdes's remarkable experiments ten years later,[2] that *it is not the presence of an irritating intrusive body that determines the formation of a pearl, but the presence in the sub-epidermal tissues of the oyster of a closed sac of the shell-secreting epidermis*, the secreting surface of which is not continuous with the secreting surface of the epidermis which lays down the shell; and that unless this epidermal sac is introduced by transplantation (as in Alverdes's and Mikimoto's methods), or is induced by the specific stimulation of a par-

A JAPANESE PEARL DIVER. NOTE THE LARGE GLASS LENS THAT IS DRAWN DOWN OVER THE EYES

ticular kind of parasite (as in the pearls in Mytilus caused by the trematode Gymnophallus), or arises by some still unknown cause or causes (as in the Ceylon pearl oyster), no irritating body introduced into the shell or tissues can be expected to become the nucleus of a pearl. In my 1912 paper[3] I showed that the vast majority of pearls from the true pearl and mother-of-pearl oysters have no recognizable nuclei of foreign origin, the bodies so often taken for such, like the dark portion of the pearl shown in Fig. 1, and the center of the pearl diagrammatically shown in Fig. 3, being composed of a kind of shell substance of pathological origin, identical with that with which the oyster repairs an injury to its shell.[4] On the other hand, some of the natural pearls I have examined contained foreign bodies which (apart from the special case of

[1]Jameson, Proceedings of the Zoological Society, 1902, Vol. I, pp. 140-166, and *Nature*, January 22, 1903, p. 280.

[2]F. Alverdes, "Versüche über die künstiche Erzeugung von Mantelperlen ber Susswassermuscheln," *Zool. Anzeiger*, Vol. XLII., No. 10, 1913, pp. 441-458.

[3]Jameson, Proceedings of the Zoological Society, 1912, pp. 260-358.

[4]It is astonishing how the "foreign nucleus" theory of pearl formation sticks, as witness the utterances of scientific men of standing which have been called forth by the recent announcement.

THE MIKIMOTO PEARL BEDS WHERE ARTIFICIALLY-INDUCED PEARLS ARE GROWN

the trematode which causes pearl sacs to form in Mytilus) ranged from diatoms and fragments of radiolarian shells and sponge spicules to quartz grains measuring, in one case, as much as 0.8 mm. in diameter. I propose to outline a theory attempting to account for the presence of these bodies in a later paper.

From the biological aspect there are two classes of pearly bodies. For the first of these, to distinguish them from true pearls, I adopted the name "blisters," familiar to pearl fishers, in 1902. Blisters (Fig. 3, *bl.*) are excrescences on the interior of the shell formed to close holes made by shell-boring animals, or to coat over intrusive objects such as grains of sand, small crabs, Fierasfer, etc., and in the case of the Buddha "pearls," Linnæus's "pearls," and the "half pearls" originally produced by Mr. Mikimoto, metal images or beads. Over such a blister the epidermis forms a little pocket directly continuous with the shell-secreting epithelium. A pearl, on the other hand (Fig. 3, *p.*), is formed in a closed sac of shell-secreting epidermis, which is embedded in the tissues of the oyster, and the nacre-secreting surface of which is not continuous with that of the epidermis that lays down the shell itself. A blister is a more or less hemispherical body passing over on all sides into the shell substance; a pearl is a concentrically deposited body, the substance of which is nowhere continuous with that of the shell. A pearl may, in the course of time, be ejected into the space between mantle and shell, and become more or less buried in the shell, forming the core of a blister; but in that case it can be dissected out from the shell layers deposited over it.

The trade distinguishes different kind of pearls according to shape and size (fine pearls, baroque pearls, seed pearls, etc.), just as biologists distinguish certain classes according to where they arise (parenchyma or mantle pearls, muscle pearls), or to the kind of shell material of which they are composed (nacreous pearls, columnar pearls, hypostracum pearls, periostracum pearls, hinge pearls). All these classes, some valuable, some worthless, are, from the biological point of view, *pearls*. Biologically speaking, the Mikimoto pearl satisfies all the conditions which go to make up a pearl as defined above. It differs from a natural pearl only in that it contains a foreign nucleus larger than any foreign nucleus which I have so far encountered in a natural pearl, and in that this nucleus is a bead of mother-of-pearl such as does not occur in Nature. Both these points could easily be remedied. A smaller nucleus could be introduced; or the nucleus might be removed after grafting the sac in the oyster; or a small natural pearl of inferior quality, or a concentrically bead of carbonate of lime, could be used as a nucleus. A trade in the worthless pearls of Mytilus might even be revived for this purpose; according to Garner they were once exported from this country to China for the manufacture of "medicine." The somewhat greater transparency, on the average, of Mikimoto pearls, when compared with natural pearls, could be remedied by either of these processes.

With regard to the question of distinguishing the Mikimoto pearl without cutting it, much vague talk as to scientific investigations has appeared in the daily press. Some of these investigations remind me of the little boy who, having learned that trains were propelled by steam, lighted a fire in his go-cart, put a kettle on it, and expected it to run by itself. Undoubtedly experienced pearl merchants, and, indeed, any zoologist who is familiar with the shells of the different species and geographical faces of pearl and mother-of-pearl oysters, can usually distinguish pearls from the Japanese pearl oyster (*Margaritifera Martensii*) from the pearls of other species, just as they can distinguish Ceylon, Australian, Central

WOMEN DIVERS LEAVING THE PEARL BOAT

A STATION WHERE THE PEARLS ARE SORTED

American, etc., pearls from each other by slight differences in color and luster; but this test only reveals that the pearls come from the Japanese pearl oyster, and cannot be used to distinguish naturally and artificially produced Japanese pearls from each other; and it would be useless for distinguishing pearls produced by the Japanese process in other species of pearl oyster from pearls naturally produced by the same species.

This natural difference is greatly intensified when the pearls are examined in ultra-violet light, for which purpose an apparatus has been designed and is already on the market. I hope shortly to be able to examine some naturally produced Japanese pearls with this apparatus. I anticipate that they will agree with the artificially produced Japanese pearls, and not with natural pearls from other localities, as this test, like the rule-of-thumb test based on the general color and luster, appears to depend on the minute differences in the structure of the nacre in different species and races of pearl oysters.

Immediately after the first announcement of the presence of these pearls in the market was made, I suggested to a press representative who called upon me that polarized light was the most hopeful line along which to seek a test that would reveal the presence of the artificial nucleus, and this suggestion was published in one of the daily papers on May 5. Immediately afterward I got into communication with Mr. A. Brammall, of the Imperial College of Science and Technology, South Kensington, who has since been engaged upon experiments which aim at determining whether polarized light can be applied to whole pearls in such a way as to furnish a test.

The behavior of polarized light when passed through *sections* of the natural and the Mikimoto pearl, respectively, was a foregone conclusion from our knowledge of the structure of their centers. When examined with polarized light between crossed Nicols, the section of a natural pearl, of course, shows throughout the cross of extinction characteristic of concentrically crystallized bodies (except in those parts which are too opaque to transmit light). A section of a Mikimoto pearl, on the other hand, shows the four arms of the cross in the outer part, which is concentrically laid down; but the mother-of-pearl bead appears alternately dark and light as the slide is rotated, according as the part of the exterior to which its laminæ are parallel is in a dark or a light sector. Mr. Brammall is not yet in a position to make a definite statement as to the practicability or otherwise of applying some modification of this process to the whole pearl. He will, of course, publish his results as soon as they are completed.

However, whether or not the pearls, produced by the Mikimoto process, which are now on the market, can be distinguished from naturally produced pearls, without destroying them, by virtue of their containing a large bead of mother-of-pearl, which behaves differently toward polarized light or toward some other variety of light, Mr. Mikimoto can easily remedy this in future by a modification of his process, such, for example, as one of those suggested above. That being so, and having in view the fact that, in the appropriate localities, "Oriental," Australian, Central American, and other varieties of pearls could be produced by the same process, it is probable that, as time goes on, more and more of the pearls coming into the market will have been produced, not by the old-fashioned methods of fishing for the "wild" pearl oyster, some of which methods have existed almost unchanged from time immemorial, but by such applications of scientific knowledge to cultivated pearl oysters as that in which Japan has given so conspicuous a lead.

Crystals, Solids and Vitreous Matter*

Basic Principles and General Phenomena Relating to Changes of Form in Matter

By A. Portevin

Matter exists in two distinct states: amorphous and crystalline.

1. In the *amorphous* state the properties exhibited (electrical, optical, mechanical, etc.), are identical in all directions around each point, and no sign of orientation is to be found no matter what the process of examination employed—in other words, the matter is *isotropic*. Examples of amorphous bodies are fluids whether liquids or gaseous, gelatine and glasses.

2. The *crystalline state* on the contrary, is characterized by clearly marked differences as regards some or all of the properties exhibited, according to the direction; in other words, the matter is *anisotropic*. (In order to be complete it is necessary to add two other sorts of anistropy outside the general case of the crystalline state, namely, the anisotropic liquid drops described by O. Lehmann and the helicoidal structures discovered by Wallerant.) In a crystal of quartz, orcalcite for example, the properties are in function of the direction and within a single direction in space they undergo a change if the crystal be revolved; they thus define the *orientation* of the crystal.

In the case of transparent bodies the best method of revealing isotropy or anisotropy, *i.e.*, of determining whether the substance is amorphous or crystalline, is to examine the optical properties by means of polarized light. Such an examination is made by observing in a polarizing microscope thin slices of the substance in question.

Crystalline matter is rarely composed of a single crystal, but is made up, instead, of the juxtaposition of crystals which differ in their orientation; familiar examples of this are furnished by marble or by a lump of sugar. These conglomerates of crystals are usually formed when fused matter is cooled; *i.e.*, when it has been previously heated in a liquid state or when it has been dissolved in a suitable liquid and then allowed to cool, or, finally, by concentrating the solution through evaporation.

*Translated for the *Scientific American Monthly* from *La Revue de l'Ingénieur* (Paris), for April, 1921.

Equilibrium Temperature of Crystallization, and Solidification or Fusion

A single definite body, whether simple or compound is capable of coexisting in the two states, liquid-amorphous and solid-crystalline at a given temperature T_s. At this temperature the liquid and the crystals are in equilibrium, *i.e.*, they are capable of remaining indefinitely in contact or as a mixture; the proportions of the mixture remain invariable provided there is no external loss or gain of heat. . . . If such a mixture be heated the crystals pass into the liquid state, *i.e.*, the temperature of fusion; if heat be subtracted by allowing the mixture to cool, the liquid will pass into crystalline state, *i.e.*, the temperature of solidification and of crystallization of the given liquid.

At this equilibrium temperature matter in the two states possesses different physical properties such as specific heat, density, viscosity, etc., and as a consequence of this, the passage from the liquid to the crystalline state and inversely is accompanied by a sudden variation of properties: Heat is liberated and there is usually a reduction in volume; this discontinuity enables us to examine the phenomena of crystallization.

It is only necessary in fact to observe in the course of the cooling of previously fused matter, either the temperature in function of the time or any property, whatever, in function of the temperature, and to note the temperature at which the representative curve obtained presents a discontinuity indicat-

ing the passage into the crystalline solid state, in order to obtain the equilibrium temperature of solidification or crystallization.

PASSAGE FROM THE AMORPHOUS STATE TO THE CRYSTALLINE STATE

As we have said the liquid and crystalline states are capable of coexistence in equilibrium only at a single temperature. (We are here considering only simple bodies or definite compounds.) Above this temperature only the amorphous liquid state is stable; hence there will be a fusion of the crystals. Below this temperature, on the contrary, the amorphous matter tends to crystallize and inversely this is effected at a certain rate which varies with the temperature, being, of course, nil at the equilibrium temperature.

In accordance with the general laws which govern all the phenomena of chemical and physical transformation, this rate is high in proportion to the elevation of the temperature, and to the absolute distance of this temperature from the equilibrium temperature.

Above the equilibrium temperature these two factors act in the same direction, so that the rate increases very rapidly with the rise in temperature: as a matter of fact it is impossible to heat a substance much above the equilibrium temperature without causing it to pass into the amorphous liquid state.

Below the equilibrium temperature these two causes operate in an inverse direction: the rate of the passage from the amorphous state to the crystalline state increases at first in proportion as the temperature falls below the equilibrium temperature, then passes through a maximum point, after which it decreases until it becomes practically nil, when the absolute distance of the temperature from the equilibrium temperature is sufficiently remote.

Thus while it is difficult to pass beyond the equilibrium temperature without causing the fusion of the crystalline matter, on the other hand it very frequently happens that the liquid may be cooled below the equilibrium point without causing crystallization to commence: in this case the liquid is in the state of *super-fusion* and the greater the distance between the actual temperature and the equilibrium temperature the higher the degree of this super-fusion.

This super-fused liquid is outside of a state of equilibrium and it tends to pass into a crystalline state, this being sometimes induced by crystals or crystalline particles thrown into it and sometimes quite spontaneous.

In the latter case the crystallization begins with the appearance of points scattered through the amorphous mass which are known as centers of *crystallization* and starting from which the crystals develop and grow with a value which varies according to the temperature. But the spontaneous formation of these crystallization centers is itself dependent upon the temperature, so that in reality the act of crystallization is characterized by two factors, both of which are functions of the temperature (Tammann):

1. The faculty of spontaneous crystallization;
2. The rate of growth of the crystal.

EXTERNAL AND FINAL FORMS OF THE GROWTH OF CRYSTALLINE ELEMENTS

Each crystallization center forms the starting point for individual crystals. There are three principal classes of these as regarded by their external form:

1. Convex *regular crystals* (Fig. 1); these are geometrical solids bounded by plain surfaces and governed by the laws of crystalline symmetry with respect to the mutual orientation of the plane surfaces. An example of these is found among alloys by definite compounds and, frequently, by the salts which separate from their solution.

2. Dendrites are crystalline structures of branching form (Fig. 2); they result from a preponderance of growth along the direction of the crystalline axes. Their general aspect recalling that of a branching fir bough. Pure metals and the solid solutions which they form within alloys crystallize in this manner. The viscoscity of the medium exerts a great influence upon the formation of dendrites so that it is possible by increasing the viscosity of the liquid—*e.g.*, by the addition of colloids to pass from convex regular crystals to dendritic forms (as in the case of the alum cited by Osmond and Cartaud and in Baumann's experiment).

3. *Sphero-crystals.*—These are groups of crystals in the form of needles radiating from a common center of crystallization (Fig. 3). The ensemble forming a small mass which is almost spherical outside and is therefore called a sphero-

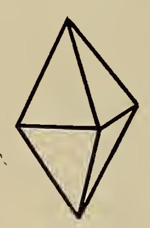


FIG. 1

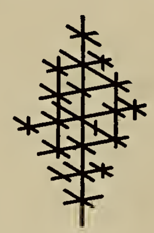


FIG. 2

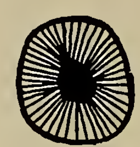


FIG. 3

FIG 4

light. The study of a great number of spherolites has shown that in reality they consist of helicoidal spirals; some bodies exhibit both simple spherolites and those marked by helicoidal spirals.

In all cases these various crystals dendrites and sphero-crystals develop from crystallization centers and cease growing by mutual limitation according to any sort of surfaces which bear no relation to the internal crystalline symmetry of the juxtaposed elements which form the whole. We thus finally obtain an aggregate of crystalline elements or grains, each grain being a crystalline individual or a spherolite, the *joints* of these grains being irregular surfaces which have no correspondence with the internal anisotropy of the elements of the structure (Allotrio-morphic crystals), whereas, during the free growth of the crystalline elements in the isotropic medium, the external forms bears a definite relation to the orientation and the crystalline symmetry—*i.e.*, with the anisotropy of the crystalline individual (Idio-morphic crystals).

As a general thing sphero-crystals are produced only when the degree of superfusion is rather strongly accentuated, and when the viscosity of the medium is, therefore, much increased; as a result of this sphero-crystals are never found in those metals and alloys which do not exhibit intensive degrees of super-fusion; on the other hand, organic compounds and silicates always have a tendency to form spherolites when super-fusion is very pronounced. (The addition of foreign substances may occasion at the time of crystallization the formation of spherolites marked by helicoidal spirals, the curve winding to the left or to the right according to whether the added substance is dextrogyrous or levogyrous according

to Wallerant.) It is even possible to observe, during the course of the cooling, polyhedric crystals at the beginning when the degree of super-fusion is slight, and then the formation at the surface of these crystals of filaments or "needles" which are normal to the facets which bound the crystal when the degree of super-fusion is most marked. (Fig. 4.)

Furthermore, it map be observed that the rapidity of growth, starting from a center of crystallization, is not strictly equal

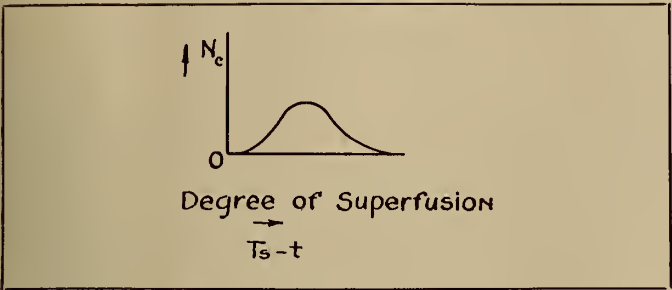


FIG. 5

in every direction, for in that case the external surface would form a perfect sphere. However, this condition is found in the sphero-crystals—the interesting form exhibited by silicates in a state of super-fusion. To simplify the discussion of the matter let us assume, as a primary approximation, that the rapidity of growth is independent of the direction, and we shall follow Tammann in calling this the *linear rapidity of crystallization.*

THE FACULTY OF SPONTANEOUS CRYSTALLIZATION—AMORPHOUS SOLIDS: GLASSES

When spontaneous crystallization occurs in a liquid which has been brought by cooling into a state of super-fusion, *i.e.,* to a temperature lower than the equilibrium temperature of the amorphous and crystalline states, there are produced, at isolated points of the mass, centers of crystallization, whose number increases in proportion to the duration of the said temperature; the power of spontaneous crystallization may be measured, therefore, by the number N_c of centers of crystallization formed in a given unit of volume during a given unit of time; this is termed by Tammann the *number of nuclei.* This number N_c which is one of the factors which determine the rate of the passage from the amorphous state to the crystalline state, varies with the temperature . . . in the following manner (Fig. 5): It increases with the degree of super-fusion, passes through a maximum and then in the case of higher degrees of super-fusion falls to zero—in other words, when the liquid has been brought to this point it loses its power of spontaneous crystallization.

In the case of those substances which readily undergo super-fusion it is possible by cooling them rapidly enough, starting from the liquid state, to bring them into a zone of temperature in which they will retain the amorphous state; in other words, they will undergo *no change of state* during the cooling process.

While the passage from the amorphous state to the crystalline state is accompanied by (and possibly revealed by) a liberation of heat during the cooling process, and a discontinuity in the variation of the physical properties with the temperature, we find, on the other hand, that if the amorphous state persists during the cooling process there is *merely a continuous variation of properties with no liberation of heat.* The viscosity alone varies in a manner which somewhat recalls a discontinuity; it undergoes, in fact, within a more or less narrow interval of temperature, a continuous but rapid increase, which causes the viscus liquid to yield finally a substance which is amorphous, non-fluid, resistant, and usually fragile—*this substance is a glass.*

Glass is a highly viscous liquid. Hence we see that glass is merely a liquid possessing a very high degree of viscosity; it is amorphous and, as a result of this, it is isotropic and inert to polarized light (that is in the absence of internal strains which occasion an irregular and transitory anisotropic, as we shall see later). The fracture of such a substance is smooth and conchoidal without any trace of grains or facets.

Inversely, if a glass be heated it becomes soft within a variable interval of temperature, and passes into the liquid-fluid state without its being possible to find upon the curve which indicates the heating process that discontinuity due to the absorption of heat, which accompanies the fusion of crystalline substances. *A glass, therefore, has no point of fusion, but merely an interval of softening* and in the same manner the cooling to the vitrious state of a liquid yields no definite point of solidification along the curve that indicates the cooling process. In the case of metals and alloys the temperatures of fusion and of solidification are determined by curves indicating the process of cooling or heating.

Such a process is inapplicable, on the contrary, for determining the solidifying temperature of a crystalline substance—such as silicate—which during the process of cooling passes into the vitreous state without crystallizing. In such a case all one can do is to determine the temperature of fusion by observing, during the process of heating, the passage from the crystalline state into the amorphous liquid state.

In brief, the cooling of a liquid may give rise to two kinds of phenomena (Fig. 6):

1. *The conservation of the amorphous state and the passage into the vitreous state with a continuous variation of the ensemble of physical properties.*
2. *The passage from the liquid and isotropic amorphous state into the solid and anisotropic crystalline state with discontinuity of the physical property, including viscosity, of course.*

In general the zone of devitrification lies very close to the zone of softening, since too great a viscosity of the medium tends to prevent crystallization.

LINEAR RATE OF CRYSTALLIZATION

The linear rate of crystallization V_c has been determined experimentally by Tammann in function of the temperature for various organic compounds; he places the super-fused substance in a U tube and observes the progress of the crystalli-

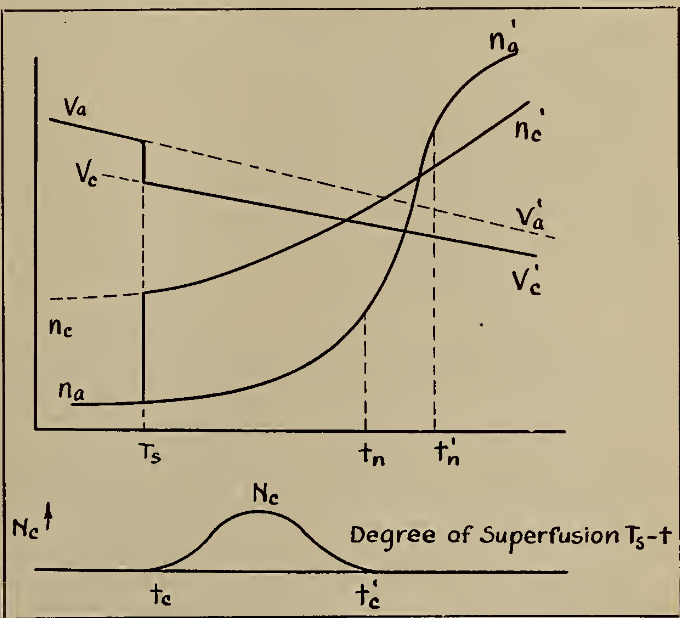


FIG. 6

zation within the tube by causing the super-fusion to cease at various temperatures by touching the free surface with a microscopic fragment of a crystal of the substance.

At the same time that the crystallization progresses the heat liberated tends to raise the temperature at the liquid-crystal contact, *i.e.,* at the limit of the crystallization. This elevation

of temperature depends upon the latent heat of fusion upon the specific heat, upon the calorific conductivity and also upon the speed of crystallization. If the maximum speed of crystallization is great and if it be found that in the area in which it decreases with the temperature the local elevation causes it to tend to increase and to cause it to attain the maximum, then in this case (great maximum speed of crystallization) the curve will not exhibit a maximum but an area of uniform maximum rate for a certain interval of temperature.

[*We are obliged to omit at this point a more or less technical discussion of the statements made, passing on to more general considerations.*—EDITOR.]

APTITUDE FOR THE FORMATION OF AMORPHOUS GLASSES—CAPACITY FOR SUPER-FUSION

It results from what has just been said that the conservation of the amorphous state consists in bringing the substance in question, without allowing it to crystallize, into the zone of temperature situated below that occupied by the curves giving N_c V_c in function of the temperature, the zone within which these two factors are practically nil. . . . The possibility of realizing this condition depends, in the first place, upon the rate of cooling, but likewise upon the values of N_c and V_c (the rate of crystallization as well as the ratio existing between these last two factors, *i.e.*, not merely upon their magnitude but also upon the relative position occupied by the curve representing their variations in function of the temperature.

Hence the aptitude for formation of an amorphous glass will be great in proportion as the maximum of N_c and V_c fail to appear simultaneously. . . . The capacity for super-fusion, in other words, the aptitude of a substance to enter the amorphous state in the course of cooling varies greatly in different substances. In simple bodies it is very slight in the case of those metals and alloys which are always in a crystalline state at any point below their point of fusion; in the case of metaloids such as boron, carbon, silicon, phosphorous, sulphur, arsenic, selenium and tellurium, they may be reduced to a pulverulent amorphous state so as to enable us to obtain glasses with sulphur and selenium. In the combinations formed with oxygen the metallic elements remain incapable of attaining an amorphous state; on the other hand the state of super-fusion is readily obtained with B_2O_3, $S_i\ O_2$, P_2O_5, As_2O_3 and this aptitude for super-fusion persists in the acid combination of these anhydrides with the metallic oxide. Certain ones among them exhibit a remarkable tendency toward the preservation of the amorphous state.

This is particularly true in the case of the silicates, the borates, and the phosphates; it is due to these properties of silicates that we are able to obtain industrial varieties of glass. The aptitude for super-fusion diminishes with the proportion of the basic oxides, so that the limits at which various silicious and boric glasses can be obtained are as follows:

Boric Glasses	*Silicious Glasses*
For an average rate of cooling	For a cooling period lasting half an hour and starting at 1000° cent.
$SiO_2 + K_2O$	$B_2O_3 + 1/6LiO_2$
$SiO_2 + 2/3Na_2O$	$B_2O_3 + 2/3ZnO$
$SiO_2 + 1/2CaO$	$B_2O_3 + 2/3CaO$
$SIO_2 + PbO$	$B_2O_3 + 2PbO$

With the rate of cooling mentioned above devitrification occurs as soon as the content of the base exceeds the limits given above. The silicate which then crystallizes is the monobasic silicate SiO_2MO.

SIZE OF THE GRAINS IN A CRYSTALLINE CONGLOMERATE

When the crystallization of the mass is complete a conglomerate of juxtapose elements is obtained resulting from the mutual limitation of the crystals of sphero-crystals which have developed starting from the centers of crystallization.

This mutual limitation results in the formation of structural elements whose external forms are approximately polyhedric and bear no relation to the internal anisotropy of the element; we have termed these grains whether they are crystalline *individuals* (convex crystals of dendrites) or radiating groups of acicular or filiform crystals (spherolites).

A grain corresponds to each center of crystallization formed after the disappearance of the amorphous state.

When these grains are all of approximately the same size their average size can be calculated provided we know the number of grains per unit of volume. The general method is to examine by the microscope a plane section of the ensemble, examining it by reflection in the case of an opaque substance and by transmitted light in a transparent or translucent substance, and then counting the number of grains visible in a given unit of surface, from which the number of grains per cubic meter can be readily found.

Small regular grains indicate high value N_c, the power of spontaneous crystallization, while irregular grains indicate low value of N_c.

The determination of the number of grains gives an idea of the magnitude of N_c but not its real value, since N_c represents the number of centers of crystallization per unit of time and per unit of volume of amorphous matter at a constant temperature. But these parameters change during the process of crystallization. Furthermore, the number of grains per unit of volume depends also upon the *rapidity* of crystallization, since this latter magnitude intervenes to determine the duration of the crystallization and by consequence the available time during which the centers of crystallization may be formed.

In case of metals and alloys the more rapid the cooling the finer the grain as a usual thing. This cannot be regarded as a general rule, however; *e.g.*, antimony acts in an exactly opposite way.

THE PROPERTIES OF MATTER IN A VITREOUS STATE

As we have already seen one of the characteristic properties of matter when in the vitreous state is that it exhibits no precise point of fusion as do crystalline substances, but on the contrary, a continuous variation of the viscosity with a rapid but progressive modification of this viscosity during an interval of temperature, known as the "softening interval." . . . This is a property of capital importance *from the point of view of the capacity for "working" of amorphous substances.* Since they are brittle at low temperature they cannot be worked by the ordinary methods of modeling, molding, drawing, or blowing except at temperatures at which they cease to be brittle without having yet become fluid.

The degree of the viscosity must vary according to the method in which the material is to be worked. Thus, it varies according to whether the operator is producing hollow bottles by a blowing process, wires or threads by traction, or still finer threads from which it is intended to form thicker threads (these thinner threads requiring a lesser degree of viscosity). Furthermore, the degree of viscosity must not undergo too rapid a modification with the temperature, since otherwise the work may be rendered very difficult and even practically impossible. . . .

The working of vitreous masses or even their cooling if the latter be too rapid, creates *internal tensions* which may persist or disappear when the surrounding temperature is reached. If they persist the glass is said to be *tempered*—but this term has not the same meaning as when applied to alloys. There is no change in the structure or constitution of temperate glass, but merely a lack of internal mechanical equilibrium, certain areas being subjected to tensile strains and others to compression strains which mutually balance each other. . . .

In pieces of glass having very high internal strains the slightest disturbance of equilibrium produced by a mechanical action, by a change of temperature, or by chemical corrosion, may cause it to break, sometimes with explosive force as in the case of Prince Rupert's tears.

In the case of transparent glasses these internal strains create an accidental double refraction, which may be shown by observation in polarized light between cross nicol prisms. . . . Sudden cooling does not cause persistent internal strains except when effected, starting at the minimum temperature at which the glass begins to be deformable under the most energetic strains which it can support without breaking. Below this temperature the internal strains produced during the cooling are temporary, ceasing as soon as all parts of the mass have regained the same temperature.

In his studies of industrial glasses (silicates and borates) Grenet has made the following observation:

1. *Softening Temperature.*—This is the temperature at which a vertical rod 1 cm. in diameter and 3 cm. in height softens under its own weight for about half its height: The load supported by the base of the standard glass prism is about 10 gr. per dq. cm. Industrially, this is the normal temperature for glass blowing and for glazing china; it also corresponds to the so-called fusion point in "Seger matches."

2. *Temperature of Rapid Annealing.*—This is the temperature at which the accidental double refraction disappears through the process of heating. . . . It is almost independent of the thickness of the specimen but is influenced by the rate of the heating. Industrially this temperature is that of the annealing of glasses and of the spreading of window glass.

3. *Temperature of Minimum Tempering.*—This is the temperature starting from which glass cooled rapidly ceases to acquire internal strains. . . by operating at a gradually increasing temperature we arrive at one where no temper can be observed and at another at which we perceive temper; the temperature of the tempering process is included between these two consecutive observations. These temperatures naturally depend upon the chemical composition.

In general the temperatures for annealing and for tempering determined by Grenet are very close to each other, the separation nearly always being less than 1000° cent. It is within this interval that the process of annealing must be conducted with extreme slowness.

OTHER FACTORS AFFECTING DEVITRIFICATION

We shall now attempt to show the double influence exerted, first:

1. By certain substances upon the rate of spontaneous crystallization, *i.e.*, the rate of devitrification;

2. The previous thermic history upon the power of spontaneous crystalization, in other words, upon the capacity for super-fusion.

Influence of Catalyzers.—If, starting from silica glass we desire to obtain crystalline silica in the form of tridymite, heating alone will not suffice; we must make use of alkaline chlorides as catalyzers or "mineralizers." The same thing is true when we desire to transform the same silica glass into quartz, which is another crystalline form of silica.

On the other hand heat alone will enable us to devitrify silica glass into crystobalite, another crystallin form of silica, provided the temperature is right, but in this case likewise the rate of devitrification depends upon the purity of the vitreous silica.

The classic researches of Ebelmen, Hautefeuille, Deville and Caron, etc., with respect to the synthesis of minerals have thrown much light upon the part played by the so-called mineralizers (borates, phosphates, carbonates, fluorides, tungstates, vanadates, chlorides, etc.).

Influence of Anterior Thermic History.—When you wish to obtain a super-fused liquid it does not suffice merely to melt the body at its fusion temperature; it is also necessary in general to heat the liquid obtained for a considerable length of time, and even to raise it to a temperature higher than that of fusion. The temperatures employed and the periods of duration of the process of heating in the liquid state react upon the capacity for super-fusion. This has been explained by assuming the persistence in the liquid of germs or particles, in other words of crystalline nuclei or starting points, which, during the process of cooling form around pre-existent centers of crystallization and which disappear only very gradually under the prolonged influence of heat in the liquid state.

As we have seen the number and size of the grains after devitrification are a function of the number of centers of crystallization formed in the amorphous medium. It results from this that the number and size of the grains may depend upon the given temperatures and durations of heating in the liquid state and also upon the number of fusions undergone by the substance—in a word the size of the grains depends upon the thermic history previous to the latest crystallization. Thus Carpenter and Edwards found that the size of the grain in certain aluminum bronzes augmented progressively in the course of the series of alternate fusions and solidifications. . . . We may cite also the influence of the casting temperature upon the size of the grains in solidified crude metals and alloys. To sum the matter up we may say that the maximum heating temperature, the duration of the heating, and the number of repeated fusions modify the capacity of superfusion and the aptitude for devitrification, and that these operations should be considered by industrial operators.

AMMONIA BY THE HYPER-PRESSURE METHOD

This note on the present status of the synthesis of ammonia by the hyper-pressure method is taken from the April 20th number of *Chemical and Metallurgical Engineering:*

"At the February 21, 1921, meeting of the French Academy of Sciences, Georges Claude presented a note on the present status of the synthesis of ammonia by the hyper-pressure method. The first practical demonstration of the process before a number of members of the Academy took place January 9, 1920, when the mixture $N_2 + 3H_2$ was first compressed to 100 atmospheres by an ordinary compressor of 60 cu. m. per hour capacity and then compressed by two hyper-compressors in series to 300 and 1,000 atm. The hyper-compressed mixture after it had been purified was passed through a catalyzer tube giving from 6 to 7 liters of liquid ammonia per hour. All the apparatus had to be placed in wells and the manipulations were difficult.

"The second demonstration took place November 20, 1920. At this time there were four catalyzing tubes instead of one. The tubes were arranged two in parallel and the other two in series and sufficient for the combination of 80 per cent of the gases treated. The tubes were placed in separate compartments located in a building on the ground. The same hyper-compressors were used as during the first demonstration, but were operated to produce 150 cu.m. per hour instead of 60. All the installation proved to be perfectly gas tight, as there was no trace of ammonia odor in the building. The production was 60 to 70 liters of liquid ammonia per hour—*i.e.*, about 1.25 tons per day.

"At the present time a great step in the process has already been realized—namely, the production by a single hyper-compressor of the two stages 100 to 300 atm. and 300 to 900 atm., which is the final pressure used. This hyper-compressor has been made by M. Le Rouge and compresses 700 cu.m. of the mixture per hour, a quantity sufficient to give 5 tons of anhydrous ammonia per day, equivalent to 25 tons of ammonium sulphate per day. The energy consumed for the compression of 710 cu.m. from 1 to 100 atm. was 187 hp. and for the compression from 100 to 900 atm. 122 hp.—*i.e.*, about ½ hp-hr. is required to compress 1 cu.m. of the mixture to 900 atm. The tightness of the installation is such that under the hardest conditions of starting and stopping of the operations the loss of gas mixture was less than 0.5 per cent. One of the four catalyzing tubes of a capacity of 5 tons NH_3 per day was tested at the same time and found to work successfully.

"Since former tests showed that it is easy to have all four tubes working simultaneously, the application of the process to large industrial units seems certain to prove successful, provided an adequate cheap source of hydrogen can be found."

Producing Soap from Petroleum*

The Synthesis of Fatty Acids from Paraffin and Other Petroleum Fractions

By K. Loeffl

During the war the Germans paid considerable attention to the production of fatty acids by the conversion of the higher aliphatic hydrocarbons, mainly paraffin, into the aliphatic carboxyplic acids, or as they are commonly called, the fatty acids. The Aktiengesellschaft für Minerolindustrie, the Chemische Fabrik Treisdorf and the Deutsche Erdol-Aktiengesellschaft were the most prominent companies who worked on this problem (for further details see *Chemiker Zeitung*, 1920, pp. 309 and 477).

In the year 1884 a patent was taken out by Schaal, in which the fundamental principles of the process were stated. The conversion of the hydrocarbons, obtained by the distillation of anthracite coal, lignite, peat, oil shales, etc., was accomplished by treating them with a current of air or oxygen at atmospheric pressures or higher, either in the hot or the cold, in the presence of the caustic alkalies, the alkaline earths, the alkaline carbonates or any other substances, which give an alkaline reaction. The soaps obtained in this way were decomposed and the free fatty acids were recovered by fractional distillation or by extraction with petroleum or other solvents.

Although the patent was a basic one, nevertheless it was not a commercial success, because the yield was altogether too small. This was not the only fault with the process, for the product was contaminated with useless by-products, the removal of which entailed too much expense to be practical. Hence, all the efforts of the numerous workers in this field were directed toward the obtaining of an increased yield. To this end, attempts were made to develop catalysts which could be used for this purpose. According to the experience of the writer, none of these catalysts produced the required results.

The really important factors in the process are as follows: The temperature, the pressure, the tubes in which the process takes place, the duration of the treatment with oxygen, the presence of water, and the presence of alkalies.

Temperature.—This is of particular importance. Tests were made at various temperatures from 60 to 200 deg. cent. The greatest yield was obtained at 115 to 120 deg. cent.

Pressure.—Pressures of 1, 2, 3 atmospheres were used, and an experiment was carried out under a vacuum. The most advantageous pressure was found to be 3 atmospheres.

Reaction Tubes.—When soluble catalysts were used, it was developed that the use of tubes in the process increased the yield and shortened the time of the reaction by half.

Duration of Oxygen Treatment.—This is an important factor, as it was found that when a pressure of three atmospheres was used and the reaction carried out in good tubes, the same yield was obtained after seven hours' treatment with oxygen, as in the experiment wherein the duration of the introduction of the gas lasted 78 hours. Furthermore, the product was considered lighter in color and less resinified.

Presence of Water.—The presence of water is essential to the success of the process. When the reaction is allowed to proceed without the addition of water, or when the water that results in the oxidation is removed as soon as it is formed, a very low yield is obtained. The product of the oxidation is much darker in color, and contains considerable quantities of polymerized dark colored products, even when the reaction takes place at scarcely over 100 deg. cent.

Presence of Alkalies.—The presence of alkalies is not essential to the success of the process according to the findings of the writer.

The process of treating the product of the oxidation in order to recover the fatty acids contained therein consisted in subjecting it first to the action of superheated steam. The lower boiling fatty acids were driven off in this way. Then, another steam distillation was carried out under a vacuum in stills, such as are used generally in the rectification of glycerine. The nature of the crude product will determine how much of the high molecular weight fatty acids will be obtained on fractionation. A fatty acid melting at 68 deg. cent. was obtained from a particularly well fractionated and well washed raw product by recrystallization from a boiling alcohol-ether mixture.

The total yield was 98 to 120 per cent, on the average 106-110 per cent of the original material. Of these 110 parts 7 to 20 per cent is water, 25 to 40 per cent, a fraction boiling at 200 deg. cent. (lower boiling fatty acids mixed with aliphatic aldehydes and ketares) and the remainder, 78 to 50 per cent, a mixture of higher boiling fatty acids, which contains 10 to 15 per cent of unsaponifiable matter.

While the process has not been applied successfully on a commercial basis as yet, nevertheless it is the opinion of the writer who is the Director of the Technical Department of the Deutschen Erdoel Aktiengesellschaft, that it is possible to manufacture fatty acids on a large scale by this method. Such a product when mixed with 10 to 20 per cent fat, cocoanut and palm kernel fatty acids forms a mixture which is very satisfactory from the standpoint of color, odor and purity for the manufacture of soaps for all rough work.

*From *Chemiker Zeitung*, 1920, pp. 561-562.

METAL PROTECTIVE PAINTS

Mr. H. A. Gardner, before the American Electrochemical Society's annual meeting brought out that high grade metal protective paints are now produced on the following four principles:

"1. Basic substances in sufficient concentration inhibit the corrosion of iron. Basic pigments that are effective for this purpose are litharge, red lead, blue lead (basic lead sulphate), white lead, zinc oxide.

"2. Chromic compounds (soluble bichromates), even in great dilution, prevent the corrosion of iron. Chromate pigments that are similarly effective when used in sufficient amounts are as follows: Basic lead chromate, normal lead chromate, zinc chromate.

"3. Neutral substances that do not ionize to acid reaction are considered inert. So-called neutral or inert pigments, such as iron oxide, which do not excite corrosion, produce with linseed oil very durable films. Such pigments include black, brown and red oxides of iron, china clay, silica, talc, and barium sulphate.

"4. Substances that form a galvanic couple with steel in the presence of moisture cause rapid corrosion. Pigments which act in this fashion (graphite, carbon black, lampblack) are used only as constituents of the finishing coats on steel surfaces when first insulated from the metal by a coat of basic or chromate pigment paint. These carbon pigments with linseed oil form very durable and water-resisting coatings."

After discussing the primer paints and finishing paints Mr. Gardner concludes that the best principles for painting iron and steel involves the use of a primer coat containing basic or chromatic pigments and the finishing coat of red oxide or black carbon pigment. Where high light reflecting power is desired lighter tinted or even white finishing paints are employed. Titanium oxide is the only white opaque pigment that is insoluble in most acid gases. 25 per cent titanium oxide precipitated on 75 per cent barium sulphate possesses tremendous hiding power and is usually applied with up to 40 per cent zinc oxide to give satisfactory hardness.

Hydrogen from Steam—II

Commercial Processes Utilizing Steam in the Production of Hydrogen

By Harry L. Barnitz, Ph.G.

(Concluded from our July issue, page 65)

In the last decade only three processes for large commercial production of hydrogen have been employed and these processes all utilize steam. They are known as the Iron Contact Process, Badische Process and the Linde-Frank-Caro process. In describing these processes the Iron Contact Process will first be considered.

The Iron Contact plant is commercially represented by two distinct types:

1. The Multiple Retort Type;
2. The Single Retort Shaft Type.

THE MULTIPLE RETORT TYPE

In the Multiple Retort Type[1] the furnace consists, primarily, of a brickwork casing (Fig. 3) containing thirty-six vertical, cast iron, pipe-like retorts. The top ends of the retorts are flanged and provided with covers for removal when the retorts have to be recharged with ferrous material. The spent material is removed through similar covers at the foot of the retorts. The thirty-six retorts are arranged in two groups, each containing two rows of nine retorts each. This division is of no practical significance. What is important is the division of the thirty-six retorts into three groups P, Q, R (Fig. 4), each group containing three of the retorts in each longitudinal row. While the groups P and Q are "reducing" the group R is "oxidizing." After running thus for a certain length of time, the group Q is changed over to "oxidizing" and the group R to "reducing," the group P remaining at the reducing setting. Thereafter P is set to oxidize and Q and R to reduce. In this way the generation of hydrogen—from the oxidizing group—is made intermittent, while the double time required for reducing is allowed to each group.

In order to facilitate the description, the three groups of retorts are, in the diagram of the plant given in Fig. 4, represented as three single retorts P, Q, R. Across the front of the furnace and external to the brickwork, there run six horizontal pipes A, B, C, D, E, F. The top end of the retort P is connected as at G to a valve H on the pipe A, and the bottom of the same retort as at J to a valve K on the pipe F. The top and bottom ends of the retort Q are similarly connected to valves on the pipes B, E, respectively, and the top and bottom ends of the retort R to valves on the pipes C, D. The three pipes A, B, C are connected at each end to vertical pipes L, M, and the three pipes D, E, F to two other vertical pipes N, S. The valves H, K are inter-connected so as to be operated together. The two other pairs are similarly connected.

The pipe N is connected with the water-gas supply. With the valve setting indicated in the diagram, the retorts P, Q are receiving water-gas from the left-hand portions of the pipes F, E, respectively. The gas rising up the retorts is reducing the ferrous oxide in them, and with the moisture and carbon dioxide, resulting from the reaction, is passing away by the left-hand portions of the pipes A, B to the pipe L. From this pipe it may be sent wholly into the furnace for heating the retorts.

The pipe M is connected with a supply of steam. With the valve setting represented in the diagram, the retort R is receiving steam from the right-hand portion of the pipe C. This steam passing downward becomes decomposed, oxidizing the metallic iron in the retort and setting free hydrogen. The hydrogen leaving the bottom of the retort reaches the right-hand portion of the pipe D and so passes into the pipe S, whence it is conducted to a purifying plant and a gasholder.

By the operation of two of the three connected pairs of valves, every ten minutes or so, the plant is capable of giving an intermittent output of hydrogen. Two practical points have, however, to be noted. In the first place, when any one of the retorts is changed over from "reducing" to "oxidizing," it is at the moment of the change filled with water-gas carrying a certain percentage of moisture and carbon dioxide. The first portion of hydrogen formed is contaminated with these substances. To avoid passing this impure gas into the pipe S, it is arranged that the valves, while they can be operated simultaneously in pairs, can also be operated separately. Thus, when the reducing period in, say, the retort P is completed, the valve H is operated to admit steam to the top of the retort, while the valve K is for the moment left untouched. The steam being at a higher pressure than the water-gas, passes down the retort and becomes converted to hydrogen. This hydrogen mixing with the water-gas in the retort causes the latter to flow back into the pipe F and the pipe N. The impure hydrogen then passes with the fresh water-gas into

[1]The multiple retort generator described is that of the Lane type.

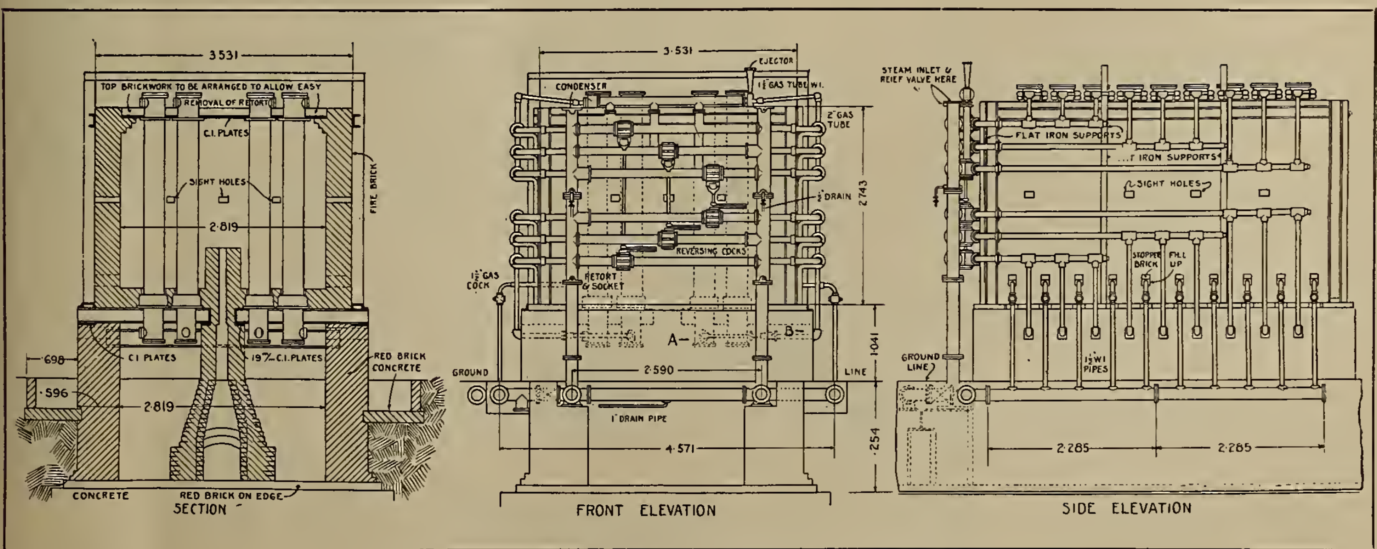


FIG. 3. A MULTIPLE RETORT HYDROGEN GENERATOR

the retort Q and the retort R—now set for reducing—and is therefore not wasted. In a short time the hydrogen generated is sufficiently pure to permit the valve K to be operated so as to allow the retort P to take up its proper function.

When passing from "oxidizing" to "reducing" the retort is at first filled with pure hydrogen. The pair of valves can, therefore, be operated simultaneously when the change from oxidizing to reducing is being made.

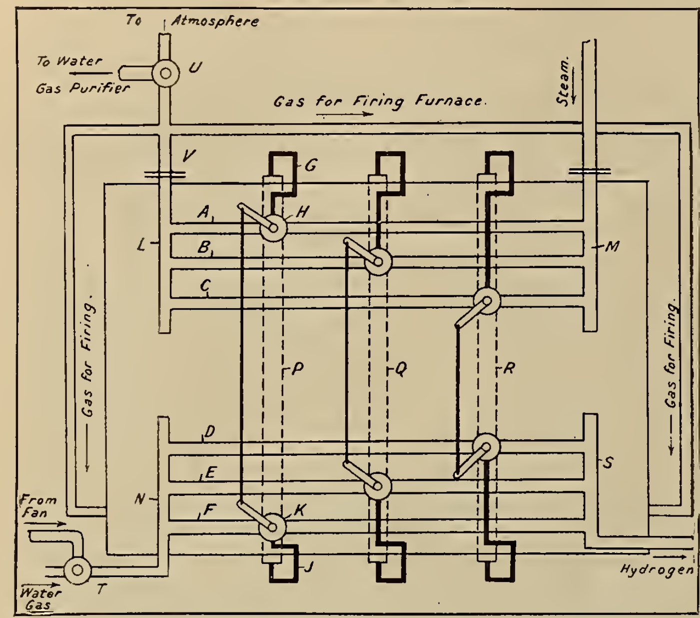


FIG. 4. DIAGRAMMATIC VIEW OF THE MULTIPLE RETORT GENERATOR

As previously stated the ferrous material, unless revivified in some way, very soon loses its activity and fails to decompose the steam, owing to the deposition on the iron of sulphur and other impurities which accumulate in the retorts during successive periods of reduction. To partially overcome this trouble air is blown at intervals through the retorts, so as to burn out the accumulated impurities. To effect this, the three-way cock T (Fig. 4), is turned to shut down the supply of water-gas and to open a branch pipe leading from a fan or other blower. The three-way cock U on the excess water-gas outlet pipe is also turned so as to close this pipe and open a branch pipe leading from a fan or other blower. The three-way cock U on the excess water-gas outlet pipe is also turned so as to close this pipe and open a branch pipe leading to the atmosphere. The air from the fan, if the retort valves are placed in the "reducing" position, then passes up through the retorts, and with the sulphur dioxide and other products derived from the impurities in the ferrous material blows off into free space.

For efficient combustion that portion of the water-gas used for firing the furnace should not be heavily laden with moisture. Accordingly, somewhere at or near the point V (Fig. 4) the excess water-gas is taken off to a condenser and returned. The condensers are placed in the immediate vicinity of the furnaces (Fig. 5).

The retorts are of cast iron and are 9 inches in internal diameter, 1½ inches thick, and 9 feet 9 inches long. Each fits into a base socket and seats therein on a joint of asbestos. The three groups of retorts P, Q, R as shown in Fig. 3, are each divided into two equal subgroups. Six pipes—see the side elevation—run horizontally along the two sides of the furnace exterior. To each of these pipes the top or the bottom ends of a sub-group of the retorts are connected. Each of the six pipes on one side of the furnace is connected to the corresponding pipe on the other side by a horizontal pipe extending across the front of the furnace. This front pipe in each instance is interrupted at a suitable point to couple up with the two flanges of the reversing cock. The top ends of the twelve retorts in each group are thus connected to one such reversing cock, while the bottom ends of the same twelve retorts are connected to a second reversing cock situated directly in line with and below the first, as shown in the front elevation in Fig. 3. In front of the six front pipes referred to, and connected to the flanges H J of the reversing cocks, lie the six pipes represented in the diagram (Fig. 4) at A B F. The vertical pipes L M N S are clearly shown in Fig. 4, the only point to notice being that in practice the pipes L and M are respectively united to the pipes N and S, and are not separated therefrom. A blank is interposed between the flanges of each pair.

Three-way cock plugs turned anti-clockwise through about 30 deg. the ports are opened, and reducing gas is sent upward through the retorts. A 60 deg. movement of the plug in the clockwise direction from this position opens the ports and causes steam to pass downward through the retorts. A fourth and fifth port are formed in the body of the reversing cock, and when the cock is in the central position, these two ports are open to one another. The flange in each of the three lower reversing cocks is open to the atmosphere. In the three upper

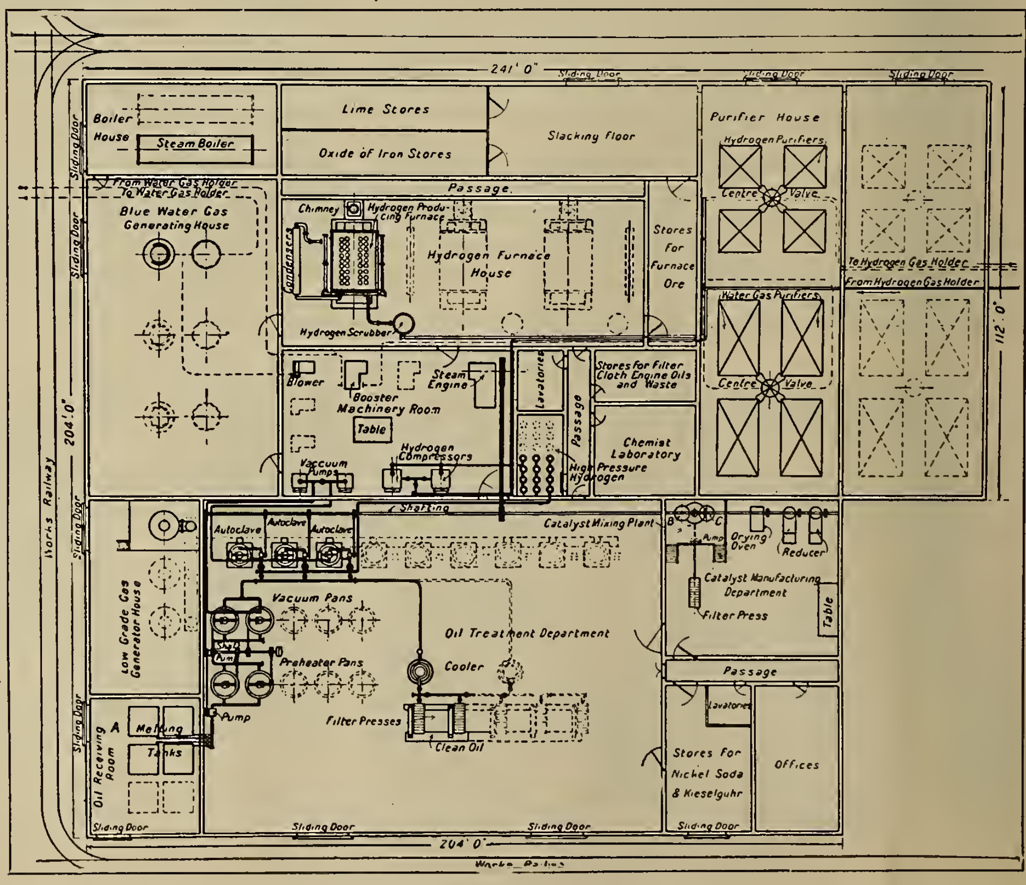


FIG. 5. GENERAL VIEW OF THE PLANT

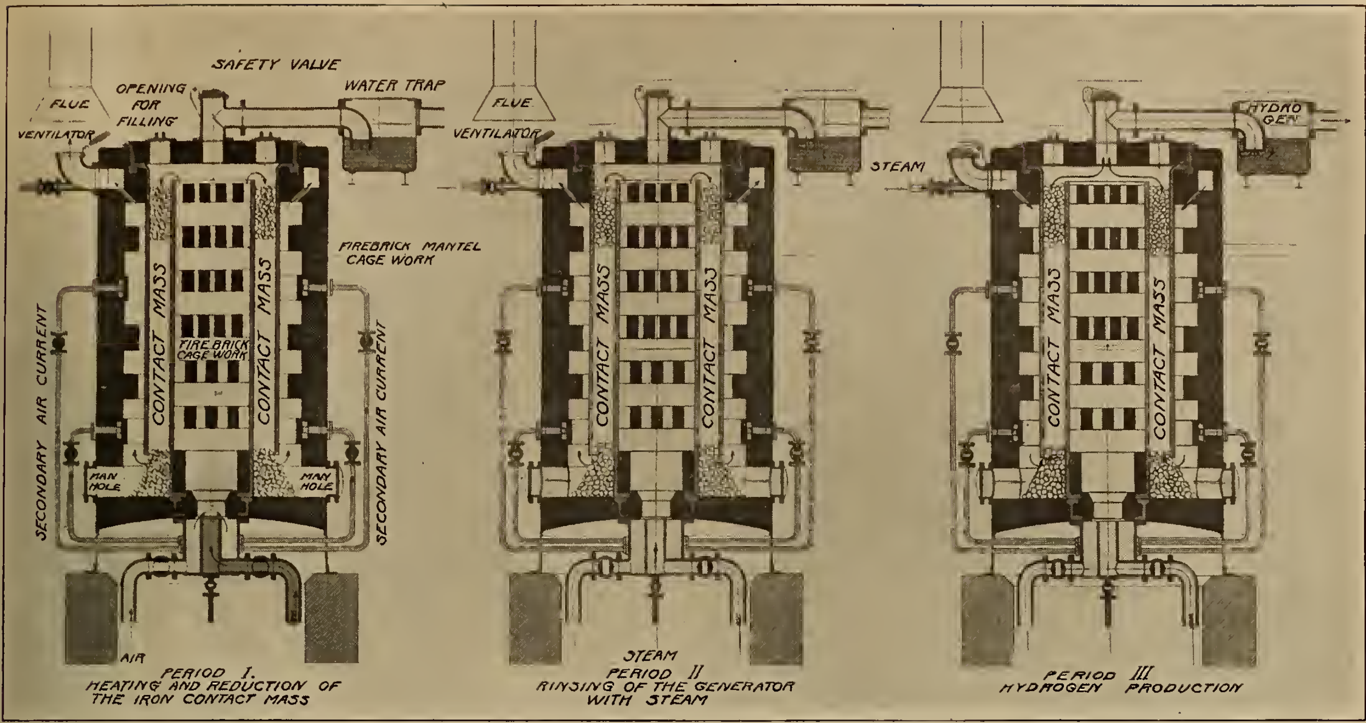


FIG. 6. THREE WORKING PERIODS OF THE LATEST TYPE OF MESSERSCHMITT HYDROGEN GENERATOR

cocks it is connected by a vertical pipe to a horizontal pipe extending across the top front edge of the furnace casing. At one end of this horizontal pipe an ejector is fitted. By turning the reversing cocks into the central position, and setting the ejector to work, air is drawn upward through the retorts for the purpose of burning out the impurities which accumulate on the ferrous material. The use of an ejector in this way instead of a fan as indicated in Fig. 4 is now the practice.

It will be noticed from the front elevation in Fig. 3 that the spindles of the three upper reversing cocks are extended down to the level of the lower cocks so that the handles of each pair are brought close together. The two cocks of each pair can thus be moved simultaneously as when passing from "oxidizing" to "reducing," or separately as when the impure hydrogen has to be blown momentarily into the water-gas pipes at the commencement of the oxidizing periods.

During the normal running of the furnace the excess water-gas is, as previously stated, made use of in part for firing the retorts. At the commencement of a run a valve near the reducing gas inlet is closed and another one on the same pipe is opened. This permits of firing the furnace with water-gas taken direct from the supply main. These means are also called into use during the slack periods, when the generation of hydrogen is interrupted. The firing may be reduced during such periods, but it is not desirable that it should be totally stopped. It is recommended that the plant should be run continuously day and night.

The plant illustrated in Fig. 5 has a rated capacity of about 3,500 cubic feet of hydrogen per hour.

THE SINGLE RETORT SHAFT TYPE

This type is represented in the Messerschmitt generator. The fundamental principles of the single-retort shaft-type hydrogen generator are, that the hydrogen is generated in a generator shaft with separate compartments for heat and contact mass, which are connected in such a way that heating, process of reduction, and generating of gas take place in the interior of one and the same apparatus.

Fig. 6 is a projective reproduction of the three working periods of a hydrogen generator of the Messerschmitt type, explaining the construction of the generator and its working methods.

In a generator shaft, lined with fire brick, two iron cylinders are built in, in a vertical position. The inner cylinder rests on the floor of the generator. Between these cylinders the iron contact mass is stored. In the interior of the inner smaller cylinder there is a cagework of fire brick which serves as storage of heat. The larger cylinder is also surrounded by fire brick cagework which is incorporated in the construction of the outside fire brick mantel of the generator. For the heating of the cagework, and for the heating and reduction of the contact mass, reducing gas (blue water) and air are introduced from underneath into the interior part of the generator, the air being in such volume as not to be sufficient for complete combustion of the heating and reducing gas (blue water-gas).

The combustion and the parts of the gas not consumed rise upward in the inner cagework, pass through the contact mass downward into the outer cagework where the rest of the gas is consumed by an additional or secondary air current, rising again upward to pass through the flue into the open. The heat is thereby imparted to the cagework, at the same time heating and reducing the contact mass. The duration of this heating and reduction process is about 20 minutes. After this the supply of heat, reduction gas and air is shut off and steam is introduced from underneath into the generator.

The steam and the carbon dioxide generated from the contact mass are driven out through the flues.

As soon as hydrogen escapes with the steam, which can be easily detected by the forming flame, the supply of gas and air is discontinued, and at the same time the ventilator leading to the flue is closed. The so-called rinsing or steaming period now begins, which requires only a few seconds, steam being passed through the apparatus as shown in the second diagram.

Then the third period begins. Steam is passed from above into the outer cagework of the generator, and the actual hydrogen production period begins. The steam coming into contact with the glowing contact mass which is now reduced, is decomposed and hydrogen is liberated with the formation of iron oxide. The outflow of the generated hydrogen takes place on the top from the center of the generator into a chamber with a water trap. From there the hydrogen passes

through a purifier into the hydrogen gas holder and is then compressed in cylinders or storage tanks. The gas period is of about 15 minutes' duration.

The process is then repeated by again introducing heating and reduction gases and air into the generator. The working method is therefore a periodical one.

The great amount of heat required during the heating and reduction periods is imparted to the contact mass and stored in the fire brick cagework. During the gas period this heat is taken up, the fire brick cagework imparting its heat to the contact mass; besides, the introduced steam which passes over the cagework becomes highly superheated and the most effective temperature for reaction is reached. The proper temperature required for this process is between 700 and 800 deg. cent., as was mentioned before. This temperature is easily reached in this generator.

Overheating, which would impair the life of the contact mass and the other materials is avoided. By the construction of the hydrogen generator of this type an even temperature of the contact mass is more readily obtained without overheating, while the required temperature is quickly imparted.

A. The generator is readily put into action, and the heating requires only a few hours.

B. The arrangement of the heating and contact compartments of this generator exclude all possibility of the hydrogens being lost or escaping.

C. The generator gives off very little heat to its surroundings, the fire brick forming an excellent insulator of heat. The workmen are therefore not troubled by heat or gases. One man can easily attend two hydrogen generators—his whole duty is to change levers for each working period and read the pyrometer. All lever positions are automatically locked, thus preventing a wrong position of ventilators.

To replace the contact mass after long use, openings for fillings are arranged on the top of the generator, and to remove it, Morton doors are placed on the lower part of the generator mantel. One coke generator and one steam boiler are sufficient for several hydrogen generators.

Theoretically, to produce 1,000 cubic feet of hydrogen at 30 inches barometric pressure and 40 deg. fahr. 116.5 lbs. of iron and 49.95 lbs. of steam are required. In practice these figures are not closely approached, the magnetic oxide of iron formed tends to shield the metallic iron from the action of the steam. In practice, to obtain a yield of 3,500 cubic feet of hydrogen per hour, approximately 5¾ tons of iron are required.

PURIFICATION OF CRUDE HYDROGEN

The crude hydrogen produced under normal working conditions by the iron contact method has approximately the composition that is given in the following table:

	Per Cent by Volume
Hydrogen	97.5
Carbon dioxide	1.5
Carbon monoxide	.5
Sulphuretted hydrogen	.03
Nitrogen (by difference)	.47
	100.00

In purifying the crude hydrogen it is first scrubbed with water to remove the mechanical contained impurities and reduce the amount of carbon dioxide. The hydrogen is then passed first through boxes containing iron oxide to absorb the sulphuretted hydrogen and then passed on through boxes containing slacked lime to absorb the carbon dioxide. After this purification the purity of the hydrogen is approximately:

Hydrogen	99.0
Carbon dioxide	nil
Carbon monoxide	.5
Sulphuretted hydrogen	trace
Nitrogen (by difference)	.5
	100.0

A plant of the iron contact method consists of three principal items:

(a) A hydrogen shaft or retort furnace containing the iron working substance which is alternately oxidized by the steam delivered from
(b) a boiler, and reduced by the products delivered from
(c) a blue water-gas generator.
Added to these are
(d) purifiers for the blue water-gas, and for the hydrogen
(e) holders for the two gases
(f) compressors for the hydrogen, and
(g) cylinders or reservoirs for the storage of the compressed hydrogen.

SUMMARY

No other method for large commercial productions of hydrogen up to the present time has been developed to replace the iron contact method for purity of the gas and low cost of production.

CATALYTIC WATER-GAS PROCESS

For the production of hydrogen from this process the material employed is steam, blue water-gas and a catalytic agent.

The steam and blue water-gas are passed over the catalytic agent—the steam is decomposed by nature of the catalyzer

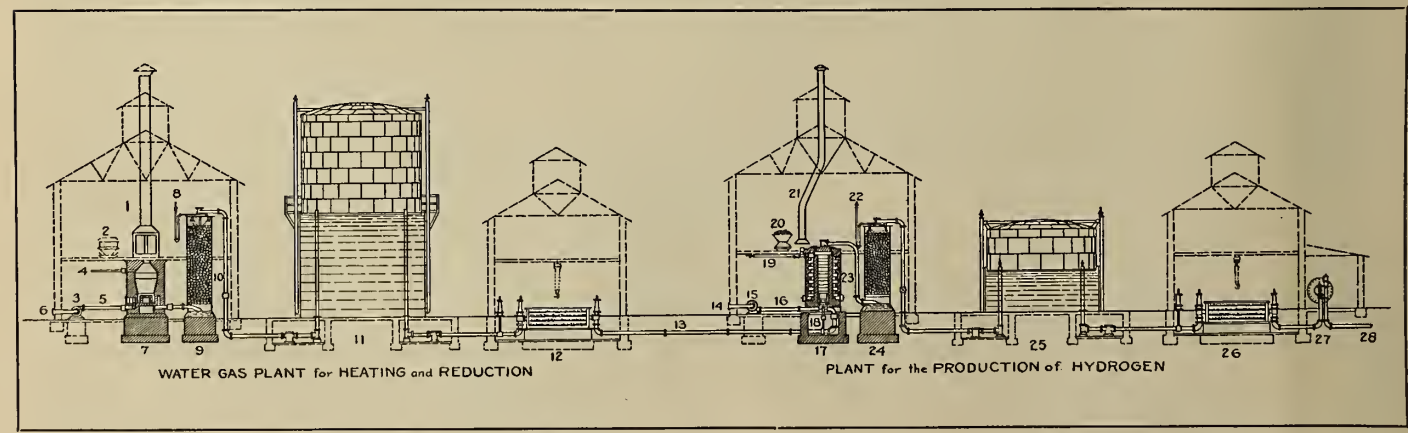


FIG. 7. DIAGRAMMATIC VIEW OF HYDROGEN PLANT JOINED TO WATER-GAS PLANT (MESSERSCHMITT PROCESS)

1. Flue for spent gases; 2, coke car; 3, fan blower; 4, steam; 5, air; 6, air intake; 7, water-gas generator; 8, water; 9, scrubber; 10, water-gas; 11, equalizing gas holder for water-gas; 12, purifier for water-gas; 13, water-gas; 14, air intake; 15, fan blower; 16, air; 17, hydrogen generator; 18, steam; 19, steam; 20, coke and spaethic iron ore car; 21, flue for spent gases; 22, water; 23, hydrogen; 24, scrubber; 25, unpurified hydrogen gas holder; 26, hydrogen purifiers; 27, melter; 28, purified hydrogen to storage tank

which in itself does not undergo any permanent change as when steam is passed over iron in the iron contact process.

The catalyst employed in the process to be discussed has a composition of the following chemicals:

Ferric nitrate	40 parts
Nickel nitrate	8 parts
Chronium nitrate	5 parts

These salts are made into a solution and precipitated with potassium carbonate, filtered and washed and formed in masses to dry. The activity of the catalyst mass is at a temperature between 400 and 500 deg. cent.

The blue water-gas is prepared in the usual manner as previously described.

Into the blue water-gas steam is introduced and the mixture passed over the catalyst with the following reaction:

$$H_2\ CO\ H_2O = 2H_2\ CO_2$$

The carbon monoxide contained in the blue water-gas is oxidized by the steam and is itself decomposed into hydrogen.

MODE OF OPERATION OF THE PROCESS

The blue water-gas combined with the proper amount of steam is passed over the catalytic mixture at a temperature between 400 and 500 deg. cent. After the reaction chamber is heated to the above temperature the oxidation of the carbon monoxide is exothermic and no more heat need be supplied from external sources. The product of the reaction is passed under pressure through water where the greater part of the carbon dioxide is absorbed.

The composition after the introduction of the steam is passed over the catalyst is:

	Per cent by Volume
Hydrogen	65
Carbon dioxide	30
Carbon monoxide	1.2-1.8
Nitrogen	2.5-5.4

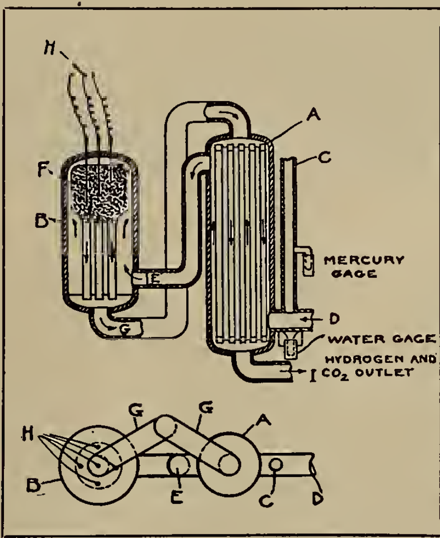


FIG. 8. CATALYTIC WATER-GAS PROCESS HYDROGEN PRODUCER

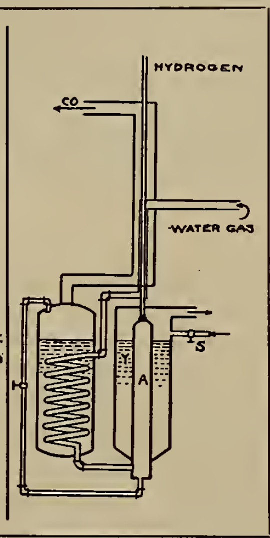


FIG. 9. HYDROGEN SEPARATOR

In the final purification the carbon dioxide is absorbed by water and passed through hydroxide of sodium or calcium. The carbon monoxide is removed except traces by passing the gas under pressure through ammonical cuprous chloride solution. The result of this final purification of the gas is approximately as follows:

	Per cent by Volume
Hydrogen	97
Nitrogen	2.7
Carbon dioxide	—
Carbon monoxide	.3

In effecting the purification of the hydrogen by the removal of carbon dioxide and carbon monoxide the hydrogen on leaving the generator is compressed at 30 to 200 atmospheres depending on the pressure required for its use, and then passed through the bottom of a tower. In this tower, packed with flints the gas meets a downward flow of water which absorbs the carbon dioxide and slight traces of sulphuretted hydrogen which are present. The gas on leaving this tower is again passed to the bottom of a second tower containing a solution of ammoniacal cuprous chloride which absorbs the carbon monoxide. The cuprous chloride solution is restored to its normal condition by passing it through a small enclosed cylindrical tank in which it gives up its carbon monoxide. To prevent any loss of ammonia evolved from the solution the gas is passed through water.

THE GENERATOR

The generator in Fig. 8 consists of a superheater or regenerator *A* and a catalytic chamber *B*, both entirely insulated with asbestos to prevent heat loss and bound by painted canvas.

Steam is introduced through pipe *C* and mixes with the blue water-gas entering pipe *D*. The mixture of steam and gas passes through the superheater *A* and flows over the refractory tubes as indicated by the arrows and the hot products of the reaction flow through the tubes in the reverse direction.

The mixed heated gases flow through pipe *E* into the catalytic chamber *B* and increasing in temperature, pass through the catalytic mixture *F*, where the reaction takes place with the evolution of heat. The gases then blow back through pipe C as indicated by the arrows into the superheater, parting with their heat to the incoming mixture of blue water-gas and steam and then to hydrogen CO_2 outlet *I* to purifiers.

Placed into the contact mixture are thermo-couples *H* to control its temperature, thereby controlling an increase or reducing the amount of steam in the incoming gas mixture.

A number of patents have been taken out relating to the general chemical reaction of the process just described, among the most important are:

Tessie du Montay—U. S. Patents, 229338, 1880; 229339, 1880; 229340, 1880. Ellis & Eldred—U. S. Patent, 854157, 1907; Pullman & Elworthy-English, U. S. Patent, 22340, 1891; Chem. Fabrik Greisheim Eleckron, U. S. Patent, 2523, 1909; Naber & Muller, German Patent, 237283, 1910.

The process and generator described in this article is based on the patents of the process of the Badische Analin & Soda Fabrik and are:

French Patent, 459918, 1913; English Patents, 27117, 1912; 27963, 1913.

SUMMARY

The advantages of this process appear to be:

1. Moderate cost of installment;
2. Continuous operation;
3. Economical, since the oxidation of the carbon monoxide is exothermic, after the reaction chamber is heated to temperature of 400 to 500 deg. cent., no more heat need be supplied from external sources. The consumption of blue water-gas is approximately 1.1 to 1.3 cubic feet per cubic foot of hydrogen, which is less if compared with consumption of 2.3 to 3.5 cubic feet of blue water-gas per cubic foot of hydrogen by the iron contact method;
4. The sulphur compounds in the blue water-gas are entirely converted into sulphuretted hydrogen and are completely absorbed by the high pressure scrubbing.

The disadvantages are:

1. The intricate operation of the process—great precautions must be taken in the preparation of both catalyzer and the blue water-gas to avoid chlorine bromine, iodine phospho-

rus, boron, arsenic and silicon in some forms, otherwise if these substances are not excluded they "poison" the catalyzer. Always an uncertainty of continuous operation due to catalyzer poisoning;

2. The plant can be operated only by those of highest technical training;

3. The purity of the hydrogen being only 97 per cent and containing 3 per cent of nitrogen is not adaptable for some purposes.

A PHYSICAL LIQUEFACTION WATER-GAS PROCESS—LINDE-FRANK CARO PROCESS

In this process water-gas, consisting almost solely of carbon monoxide, CO, and hydrogen, is cooled and compressed until the carbon monoxide is liquefied, while the hydrogen still remains gaseous and can be drawn off. The apparatus consists essentially of a water-gas plant (Fig. 9) and a plant for the separation of the hydrogen from the carbon monoxide gas.

The water-gas from the producer is first washed and purified, as stated in the production of blue water-gas.

The hydrogen is separated from the rest of the gases by compression and cooling. The boiling point of hydrogen, 253 deg. cent. is much lower than that of the other constituents of the blue water-gas, that of carbon monoxide being 190 deg. cent. and that of nitrogen 195.5 deg. cent. On cooling compressed water-gas to the temperature of liquid air, 191.4 deg. cent. all of the constituents except the hydrogen are liquefied. The hydrogen thus easily separated in the gaseous state is of a high degree of purity.

Before this separation by cooling is attempted the water-gas undergoes preliminary treatment for the extraction of carbon dioxide which, if not removed, would be in a solid state and would therefore block the narrow tubes of the rectifying apparatus. The removal of the carbon dioxide gas is effected for the most part by compressing the water-gas, in contact with cold water, up to a pressure of 20 atmospheres. At high pressure water absorbs carbon dioxide more easily than at atmospheric pressure, hence the quantity of water required for absorption is reduced. The small traces of carbon dioxide, sulphuretted hydrogen still remaining in the water-gas are extracted by passing the latter through tubes containing sodium hydroxide. This dried compressed water-gas then passes through the temperature exchanger of the separator to the coil (Fig. 9) immersed in a bath containing liquid carbon monoxide.

In this coil the carbon monoxide is almost entirely condensed and collects in the bottom of the liquefier *A*, whence it can be discharged by means of a cock into the bath surrounding the coil. The remaining gas passes through the liquefier *A* surrounded by liquid nitrogen evaporating under vacuum. In this way more carbon monoxide is condensed, and the gas issuing at the top is composed of about 97 per cent hydrogen. The remaining carbon monoxide can be removed by passing over soda lime.

This method of compressing water-gas and cooling it by liquid air produces hydrogen 97 per cent pure as will be seen from the following:

	Per Cent by Volume
Hydrogen	97.0
Nitrogen	1.0
Carbon monoxide	2.0

PURIFICATION OF THE HYDROGEN

Where hydrogen of over 99 per cent is required it is necessary to remove the carbon monoxide by passing the gas through heated soda lime, where the carbon is absorbed in accordance to the equation:

$$2NaOH + CO = Na_2CO_3 + H_2$$

Purification may also be effected by passing the gas through heated calcium carbide (over 300 deg. cent.) which removes both the carbon monoxide and nitrogen.

After purification (with soda lime) the analysis of the gas is:

	Per Cent by Volume
Hydrogen	99.2-99.4
Carbon monoxide	nil
Nitrogen	0.8- 0.6

with a specific gravity of 0.77 to 0.79.

As indicated above the hydrogen after purification will average in purity 99.2-99.4. This rectification is costly.

The hydrogen leaves the apparatus under a pressure of 25 atmospheres, which is a considerable saving of power when cylinders have to be filled with gas under pressure.

The residual gases which have been separated by liquefaction consist chiefly of carbon monoxide. They are passed into a small gasholder and used in a gas engine for providing the power required for the plant. With small installations these residual gases have to be supplemented by producer gas, which can be formed to the extent to which it is required in the blue water-gas generator.

The hydrogen plant can be run either continuously or intermittently but it is advisable to shut down the hydrogen separating section every seven days in order that all the worn tubes may be cleaned. A second unit of this section of the plant is kept in reserve for use while the first unit is being cleaned. The plant can quickly be brought into action and its output accommodated to requirements. Plants of this type are constructed in stationary and portable form.

It has already been explained that the hydrogen is obtained by the separation by liquefaction of a gas rich in carbon monoxide. This gas, which is ordinarily used for driving the plant may be utilized as a source of energy for the manufacture of oxygen and nitrogen by rectification of the liquid air which is used for cooling in the separating apparatus. This combination of recovery of hydrogen, oxygen and nitrogen in different proportions makes it possible to apply the liquefaction water-gas process not only in cases in which hydrogen only is needed, but also in some instances for metallurgical purposes in which hydrogen and oxygen are used for high temperature work. The cost of hydrogen from this process depends upon the size of the plant. Estimating the cost of hydrogen from a plant producing 3,500 cubic feet per hour, not taking into consideration depreciation, etc., a unit volume of blue water-gas yields 0.4 volume of hydrogen of 97 per cent purity, or, on the basis of a coke consumption of 35 pounds per 1,000 cubic feet of water-gas, the hydrogen yield is 25,500 cubic feet per ton of coke.

SUMMARY

1. A plant for the production of hydrogen by the Linde-Frank-Caro process requires highest technical skill to operate;

2. The plant is very costly and intricate;

3. The purity of the hydrogen being only 97 per cent pure is not adaptable for all industrial uses. Therefore to bring the hydrogen to higher degree of purity requires repurifying which is costly.

DIESEL ENGINE BLOW-LAMP

In the *Shipbuilding and Shipping Record* for February 10, 1921, there appears a description of an improved blow-lamp for Diesel engines. The simplicity of this heater is one of its principal advantages. The container, filled with parafin is mounted on the cylinder. To start up the engine, a little asbestos fiber is fixed in a suitable position on the cylinder and is soaked with methylated spirit or paraffin and ignited with a match. The paraffin in the container is subjected to pressure and on opening the valve a finely atomized spray plays on the burning asbestos. The resulting flame is said to be sufficiently intense to enable any size of British Kromhout engine to start within 4 minutes.—Abstracted through the *Technical Review*.

THE AERATOR AT KENSICO RESERVOIR

Safeguarding the City's Water Supply

What the City of New York Does to Preserve the Purity of Its Drinking Water

THE City of New York has an ever watchful little band of scientists, who, without any display or striving for publicity perform as important a part as guardians of the public health as do the quarantine officers of the port. So quietly is all the immense volume of work carried on that few people know that there are three laboratories which guard the water at its source, during its path and finally near the ultimate consumer. The laboratories carry on a variety of work which is interchanged when necessary. It is interesting to go over the subject in detail with a qualified expert like Dr. Frank E. Hale, Chief Chemist of the Department of Water Supply, Gas and Electricity, and Director of Laboratories the largest of which, the Mount Prospect Laboratory, is situated in Brooklyn. All of what follows is abstracted from a paper which he read before the Municipal Engineers on May 28, 1919, and which was printed in full in *The Municipal Engineers Journal.* The figures are now somewhat larger than those of 1919 which are given throughout, but the main facts and statistics remain unchanged.

COMPLEXITY OF SUPPLY

The available supply for New York City is at present about 800 million gallons per day with a consumption of about 600 million gallons daily, and with the development of the Schoharie watershed 250 million gallons daily additional supply will be added, making a grand total of 1,050 million gallons daily. The present available supply is procurable as follows:

Croton watershed, 336 million gallons daily; Bronx and Byram watersheds, 18 million gallons; Esopus watershed, 250 million gallons; Long Island watersheds, including Queens (in reserve), 150 million gallons; Staten Island watershed (in reserve), 12 million gallons; private water companies, 34 million gallons; making a total of 800 million gallons daily.

The supervision by the Department of Water Supply, Gas and Electricity as to the quality of the water supply extends to the private companies of which there are seven in Brooklyn and Queens operating eighteen separate pumping stations. These supplies are entirely from wells. The Long Island Municipal watersheds comprise the Ridgewood system (two infiltration galleries, nineteen well systems and twelve ponds andl reservoirs), Oakland Lake in Queens, and the separate well systems of Brooklyn and Queens (three in Brooklyn and two in Queens). The Staten Island watershed is composed entirely of well systems (five). The Ridgewood system, at present in reserve, derives three-quarters of the water from underground sources. About 35 million gallons daily are available from the Massapequa and Wantagh infiltration galleries. These are really horizontal wells extending for six miles parallel to the south shore of Long Island, intercepting the flow at a depth of fifteen to twenty feet below the surface of the ground and collecting the water through open joints of tile pipe protected by coarse gravel. The area of the Ridgewood system is 168 square miles and must be carefully watched, particularly because of its lack of adequate storage and its nearness to the city, Massapequa pond lying only 27 miles east of the Ridgewood reservoirs. The well systems that are situated within the Boroughs of Brooklyn, Queens and Richmond pump directly to the distribution systems, which is also true of the private companies.

Stringent rules and regulations have been promulgated and are enforced to prevent any contamination of drinking water supplied to any part of New York. These rules require all sewage-disposal systems to be operated and maintained in a manner approved by the Department and require new sewage-disposal systems and alterations of those in existence to be approved by the Department. The rules regulate the disposal of human excreta, house slops, sink, laundry, garage and stable waste, all polluted liquids, dead animals,

manure, garbage, compost, vegetable or any putrescible matter. drainage from stables, pig-sties, poultry, barn-yards, slaughter houses, standing places for horses, cattle, etc., factory waste, washing of cloths or unclean objects, bathing, swimming, etc.

CORNER OF THE BACTERIOLOGICAL LABORATORY AT ASHOKAN WHICH RESEMBLES AN OPERATING ROOM IN NEATNESS

Distances are specified and penalties provided. Most of the rules are stated negatively indicating what may not be done.

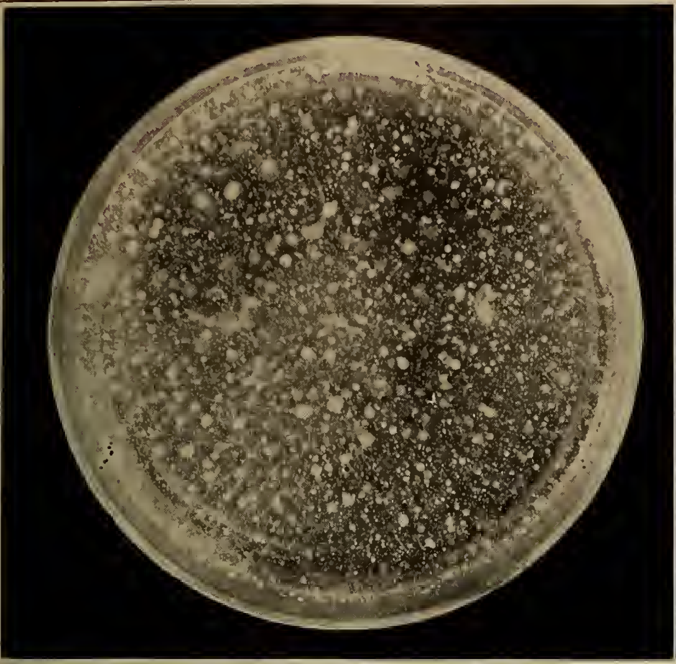
SANITARY FORCES

The Brooklyn, Queens and Richmond watersheds are under the control of the respective borough engineers. The Croton and Catskill distribution system likewise are under borough control. The Croton, Bronx and Esopus watersheds are under jurisdiction of a division engineer who has an assistant engineer over the Croton watershed and an assistant engineer over the Esopus watershed. Uniformed inspectors look after the watersheds of surface supplies and tramp the streams and adjoining territory. The Croton watershed is divided into 24 sanitary inspectional districts, with an employee for each district who is held responsible for the sanitary conditions within his district. Each inspector is required to follow daily the prescribed route, averaging about eleven miles, and to report in writing his investigations. Each route in a district is covered periodically, usually once a week. Every case of typhoid is investigated, waste disposal looked after, disinfectants furnished and full information recorded. Sewage disposal, both public and private, is carefully planned, supervised and in some cases operated, and chlorination plants operated or supervised. The Bronx and Byram watershed has five inspectional districts, and contains sewage-disposal and chlorination plants. The Esopus watershed similarly is looked after by an inspectional force covering seven districts, and a chlorinating plant is operated. The Brooklyn watershed, when in operation, is similarly under daily patrol, filtration plants and chlorination plants are operated, and pan system and cesspools cared for by scavengers. Although in reserve, a certain amount of inspection is at present maintained.

LABORATORIES

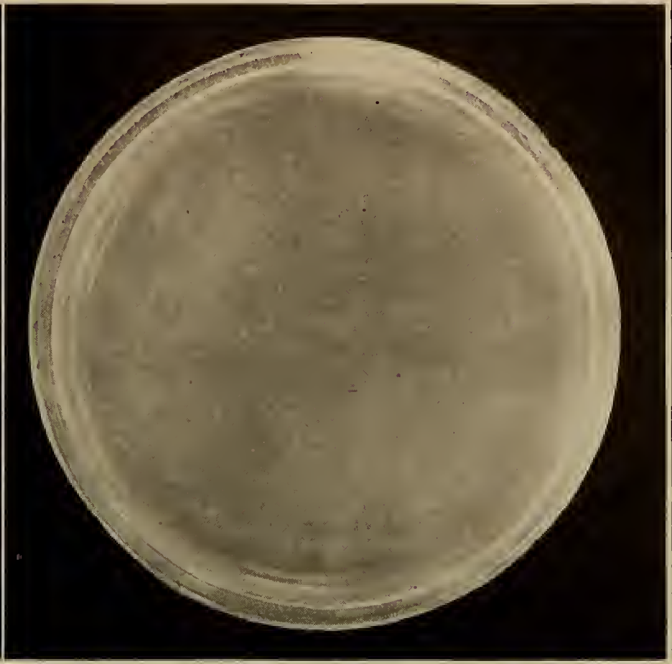
At present there are three laboratories. Mt. Prospect, the main laboratory is situated in Brooklyn. Here are analyzed completely all samples of water from the distribution systems of the city, and from Long Island, Queens and Richmond watersheds. In addition, during the war, all chemical analyses of water from the Croton, Bronx and Esopus watersheds were handled at the main laboratory. Problems of research, budgetary matters, supplies, reports, etc., are centralized here. At the Mt. Kisco Laboratory, situated at Mt. Kisco, N. Y., are handled complete sewage analyses, including chemical work, of samples from disposal plants on the Croton and Bronx watersheds and all bacteriological samples from these two watersheds. At present the physical and microscopical analyses of samples from the Croton and Bronx watersheds are divided, half and half, between the Mt. Kisco and Mt. Prospect laboratories. The Catskill laboratory is situated at Ashokan reservoir and handles the bacteriological and physical analyses of samples from the Esopus watershed. The chemical and microscopical work is performed at the Mt. Prospect laboratory with the exception of certain special chemical tests in connection with the operation of the Phoenicia chlorination plant. This laboratory is new and beautifully equipped throughout with electrical apparatus. The current is derived

CATSKILL LABORATORY IN A MEZZANINE GALLERY IN THE LOWER GATE HOUSE AT ASHOKAN



PHOTOMICROGRAPH OF WATER FROM A POLLUTED STREAM

2,000 Bacteria per cubic centimeter incubated at blood temperature, 37 deg. cent.



SAME AFTER TESTING WITH LIQUID CHLORINE

Seventeen pounds of chlorine are used to each million gallons of water

from water power. Equipment is also at hand for sewage analyses in case such should become necessary for this watershed.

CHARACTER OF ANALYSES

The analysis of the water samples is very complete and may be grouped as follows:

1. *Physical.*—The physical examination includes turbidity, color and odor. This examination is related to the æsthetic senses, qualities most readily affecting the consumer.

2. *Chemical.*—The chemical examination includes determination of nitrogen in all its forms (free ammonia, albuminoid ammonia, nitrite and nitrate), chlorine, hardness, alkalinity, iron, total solids, loss on ignition and fixed solids. On certain samples, tests are also included for free carbonic acid, free chlorine, total lime, heavy metals, silica and sulphates. The chemical analysis is particularly useful in judging of the history of any particular water and its suitability for boilers or other industrial use. Many of the above determinations are influenced by the number of people dwelling upon the watershed, as well as by the amount of contamination that may reach the water. In well waters the amount of nitrate indicates the degree of oxidation of organic matter, that is, the amount of contamination and purification the water has undergone. Many samples of leaks are sent to the laboratory for identification. These are taken from cellars, excavations for construction work, underground conduits, subways, etc., and examined to ascertain whether their source is city water, sewage, or underground water. Apparently the pressure of the Catskill water has increased the number of leaks, since there were 407 such samples during 1918 compared with 280 in 1917 and 114 in 1916. Both the chemical and microscopical analyses are invaluable in this connection.

Again the chemical analyses have assisted in preventing the stealing of city water by barges supplying boats in the harbor and by industrial concerns, and in distinguishing between city water and private supplies when the boundary services were uncertain.

3. *Bacterial.*—The bacteriological examination includes the total bacteria growing on agar at blood temperature (37 deg. cent.) and in special cases, particularly well waters, the total bacteria growing on jelly at ordinary temperature (20 deg. cent.). Liquefiers in a well water indicate surface drainage to the ground water. Specific search is made for the various species belonging to the intestinal group of bacteria usually termed "*B. coli*," including twenty or more forms which may be grouped under the species *B. communior*, *B. communis*, *B. latis-aerogenes*, and *B. acidi-lactici*. Specific search is also made for *B. typhi*, *B. para-typhi*, *B. sporogenes*, *B. welchii*, and it is hoped eventually that *B. dysenteriae* may be included.

4. *Microscopical.*—The microscopic work includes the identification and estimation of the quantity of the various thousands of microscopic plant growths which may be present in the water supply. These are important in connection with taste and odor and will be mentioned below in more detail.

MICROSCOPIC ORGANISMS

Complaints are received at periods of disagreeable taste and odor in the water of turbidity, scum, oil, etc. Many of these

WATER SAMPLING DEVICE USED AT THE RESERVOIRS

The water comes through the small bottle into the large one and the residual water in small bottle gives sample from the desired depth

are investigated by the laboratory division as well as by the borough engineers. Frequently the trouble is due to "dead ends" and is readily remedied by flushing through hydrants in the vicinity. But more often the trouble is caused by some microscopic organism. All reservoirs and sources of supply are regularly examined and trouble is usually foreseen and complaints prevented. Certain reservoirs may be by-passed.

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CLEANING THE SCREENS AT THE KENSICO RESERVOIR

These screens take out larger particles, also many fish

Draft may be changed from one basin to another or from the surface to a depth. Aeration has been used for a few years not only, if possible, to remove odor, but to actually break up and disintegrate certain fragile forms. Thus *uroglena* has been completely destroyed and *asterionella* disintegrated. Specific growths may be killed by copper sulphate which is dragged in burlap bags rapidly through the water by means of boats. Thousands of pounds are used annually by the Department for this purpose. Each organism has its own required dose ranging from one part in one million to one part in twenty million by weight of copper sulphate to water. On large reservoirs local sections may be treated and frequently the dose is figured on the upper ten feet only. In fact, certain types, *cyanophyceae*, are most abundant near the surface, being kept afloat by the oxygen gas which they give off. During 1920 and 1921 successful control of microscopic organisms in the Catskill water has been obtained by adding copper sulphate to the water in the aqueduct shortly before entering Kensico Reservoir by means of automatic dry feed at the Pleasantville plant.

The organisms which trouble the New York City supply the most are:

Diatoms

- *Asterionella*, *Tabellaria* } produce geranium to grassy and fishy odor.

Cyanophyceae

- *Anabaena*, *Aphanizomenon* } produce grassy to pig-pen odor.

Protozoa

- *Uroglena* produces fishy odor.
- *Synura* produces cucumber and bitter taste.
- *Dinobryon* produces oily and fishy taste.

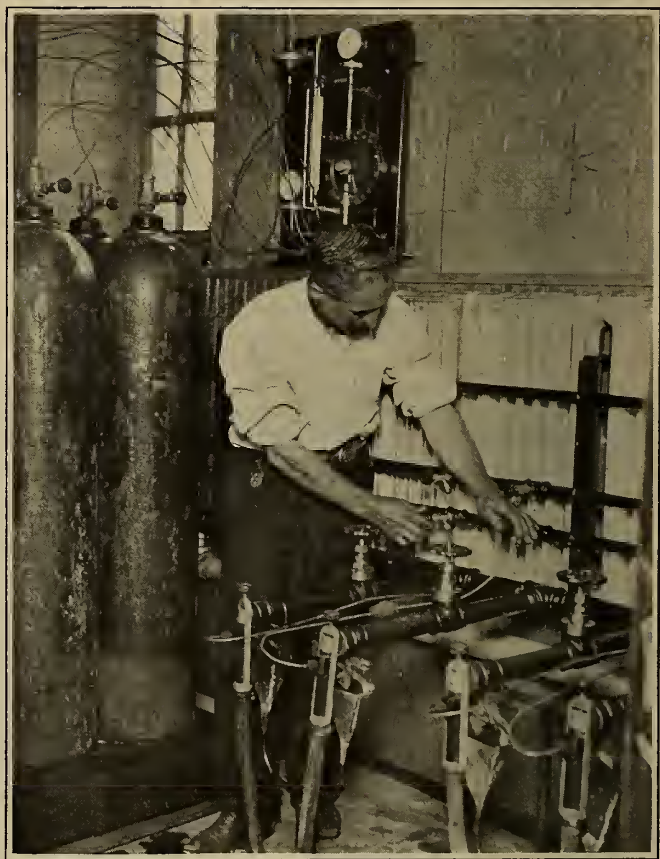
Schizomycetes (*Crenothrix*) clogs well systems.

All of the above, except *crenothrix* have troubled the supply during the last two years.

STORAGE

The first and greatest safeguard which the city supply possesses is the extent of storage on its watersheds. This is not true of the Long Island surface watershed. The Croton watershed contains twelve reservoirs and six lakes, with a total storage capacity of 104 billion gallons, equivalent to one and one-half years' storage at the present rate of draft. Croton Lake itself is twenty miles long, including the upper portion, termed Muscoot Reservoir, and possesses nearly one-third of the total storage. Since the introduction of the Catskill supply and consequent smaller draft upon the Croton supply, plans have been formulated in order to utilize the storage facilities in the best manner possible. Each reservoir is kept near a predetermined level such that it will have sufficient storage capacity to permit of at least two weeks' sedimentation after all but the very severest rainfall.

Ashokan Reservoir has an available capacity of 128 billion gallons equivalent to 256 days (two-thirds of a year) at a draft of 500 million gallons daily. When the Esopus River pours



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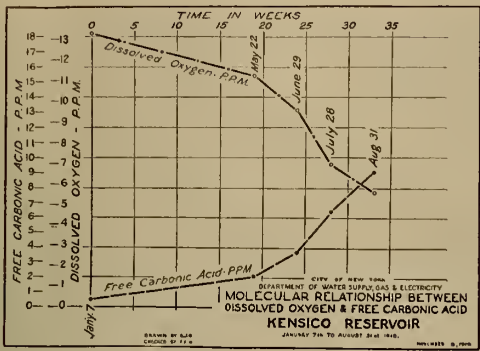
USING LIQUID CHLORINE TO STERILIZE NEW YORK'S WATER SUPPLY

its muddy water during heavy storms into the head of Ashokan Reservoir a sharp line of demarcation forms at the upper end of the reservoir.

THERMOCLINE STUDIES

Many changes take place in stored water at different depths and extensive studies have been made at both Croton Lake and Kensico Reservoir and a few at Ashokan Reservoir. During the summer the surface-water becomes warmer and

through the action of the wind, rain and heat, disturbances take place to a moderate depth, usually from fifteen to thirty feet below the surface. This point is termed the thermocline. Below this point the water is stagnant and decreases in temperature, sharply at first, then more gradually, to the bottom. Above the thermocline the water becomes warm and high in microscopic organisms; below, it is clear, cold and lower in microscopic organisms. The dissolved oxygen becomes exhausted at the bottom and frequently just below the thermocline.



As the oxygen decreases, carbonic acid increases. Knowledge of the above has caused the Department during recent years to draw as much as possible from deep water in the reservoirs, thus obtaining water of better quality. In the fall colder temperatures cause the water to overturn so that it becomes of uniform temperature and quality from top to bottom, and this continues throughout the winter.

AERATION

In connection with the headworks of the Catskill aqueduct at both Ashokan and Kensico Reservoirs, aerators were built capable of handling all the water carried by the aqueduct. These are great fountain basins, approximately 500 feet long by 250 feet wide, each containing 1,600 nozzles through which the water is jetted and sprayed as high as thirty feet into the air. These aerators permit water to be drawn from any depth in a reservoir, increasing the oxygen when low, decreasing the carbonic acid (a corrosive element) and removing musty tastes and odors or undesirable gases like hydrogen sulphide. These aerators have actually helped to break up and lessen certain microscopic organisms.

FORESTATION

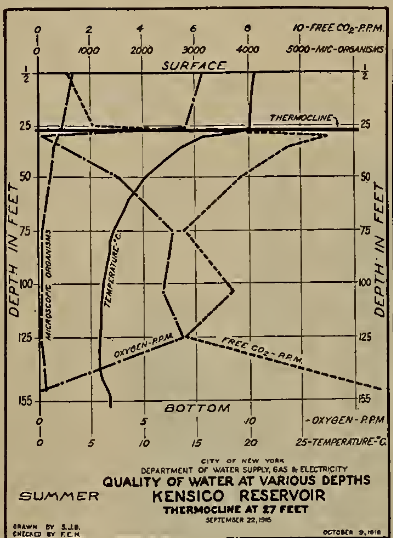
Forests equalize run-off, increase humidity and thus decrease the rate of evaporation. Coniferous trees transpire less moisture than grass, thereby leaving more water in the ground to appear as run-off. When planted between reservoirs and highways they provide a dust screen which prevents the entrance of much road detritus into the reservoirs. When planted thickly they render access to the lake shore difficult. Trees help to prevent the scouring of banks by heavy rainfall and the necessarily turbid water resulting. In addition there is of course the beautifying of the general landscape, particularly when evergreens are present. New York City controls over 15,000 acres on the Ashokan watershed. Upon less than half of this exists a native forest of second growth hemlock, white pine, oak and maple. Chestnut trees have been almost entirely exterminated by the chestnut-bark blight which suddenly sprang up a few years ago. The Board of Water Supply expended considerable effort in reforestation, growing from seed several hundred thousand trees a year. Over a million and a half evergreen trees, two-thirds of which were species of pine, have been planted, particularly on the shores of the reservoir. Likewise at Kensico Reservoir the Board of Water Supply planted over 800 acres with white, red and Scotch pine and Norway spruce. Beginning in 1912 forestation was started on the Croton watershed, particularly near villages, reservoirs and adjacent to the public roads. Three-year-old and four-year-old transplants have been used of white, red, and Scotch pine and spruce obtained from the State Conservation Commission. This work will probably require considerable attention in the future, particularly because of the possible ravages of insects and parasite fungi and of the destruction by fire.

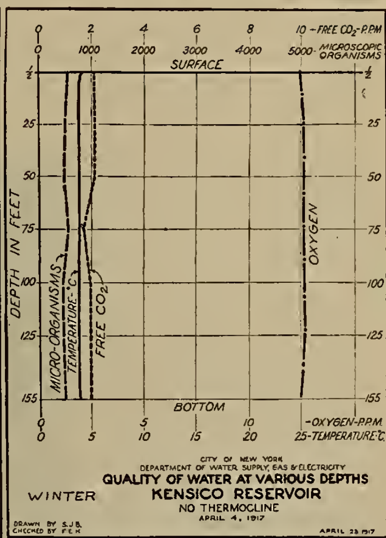
COAGULATION PLANT

In case Ashokan Reservoir should become turbid through wind and wave action on deposited silt during times of low water, an alum coagulating plant was installed on the aqueduct at Pleasantville, about thirty minutes flow above the Catskill influent to Kensico Reservoir. It was designed to add alum to the water which would be flocked by the time it reached Kensico, entangling the turbidity, which would then settle in Kensico Reservoir. The plant has been tested and its effect on the water studied, but otherwise there has been no occasion to use it for this purpose.

SEWAGE DISPOSAL

Extensive means are taken to prevent sewage from entering the water and adequate purification insisted upon where this is impossible. The Croton watershed has numerous sewage plants installed, of all types, depending upon the existing local conditions. Hundreds of houses and hotels have been looked after. Pan closets, chemical closets, tight cesspools, leaching cesspools, septic tanks, open trenches, subsurface irrigation tile drains, trickling filters, contact beds, sedimentation tanks, Imhoff tanks, sand filters, chlorination, etc., are all practiced. About the only methods not used are the chemical precipitation, activated sludge, yeast process, sulphite process, and electrolytic-lime process, and most of these





are too new or untried. Several of the larger plants are under strict analytical control at every step of the process and in several instances the effluents are purer than the streams into which they flow.

CHLORINATION

All surface water before delivery to the consumer is chlorinated, sometimes more than once. In the Borough of Richmond, the well water of the West New Brighton pumping station was provided with facilities for chlorination because of possible contamination of the suction main while crossing polluted brook water. This station is now in reserve. In the Borough of Queens, the water of Oakland Lake after filtration was chlorinated. This supply is in reserve. On the Long Island watershed all water east of Milburn was chlorinated at the Milburn pumping station; also the water of the conduit at

Smith's Pond pumping station. In addition, the water of Watt's Pond, with which the water of Valley Stream Pond was usually mixed, was separately chlorinated. These supplies are all now in reserve. On the Croton watershed, Tonetta Brook at Brewster, Katonah Brook at Katonah and the Kisco River at Mt. Kisco are chlorinated. Lake Gleneida, on the shores of which Carmel is situated, is chlorinated as it flows into West Branch Reservoir. The entire Croton supply is treated with liquid chlorine at Dunwoodie, a point at which the old and new Croton aqueducts closely parallel one another. This plant was originally operated in 1912 with bleach and in 1916 the treatment was changed to liquid chlorine. There are nine units, each regulating gas from ten tanks of liquid chlorine. The latter stand on platform scales and the loss in weight of chlorine is taken at intervals to check the delivery of the apparatus. The gas enters the water at a depth through a battery of 45 diffusers. The cost of such treatment in normal times is about 25 cents per million gallons, exclusive of interest, depreciation and repair. The Esopus River on the Catskill watershed is chlorinated below Phoenicia with bleach. The plant is temporary and will be continued so long as unpurified sewage enters the stream, as is the case at Pine Hill and Chichester. The entire Catskill supply is again chlorinated in the aqueduct just after leaving Kensico Reservoir and following aeration. This plant is similar to the Dunwoodie plant except that the gas is first forced into solution in water in pipes through the use of injectors, and the solution flows through hose into the water of the aqueduct. Thorough admixture is brought about by passage through a Venturi section built into the aqueduct at this point. The water leaving Kensico Reservoir via the 48-inch pipe line at the dam is also chlorinated by liquid chlorine.

FILTRATION

In the Borough of Queens the water of Oakland Lake is passed through a slow-sand filter, operated at a five-million-gallons-per-acre-per-day rate, bacterial efficiency being perfected by chlorination with liquid chlorine.

Our filters were originally built to treat polluted portions of the Brooklyn supply, two of the slow-sand-type—the Hempstead and the Forest Stream filter plants—and two of the rapid or mechanical type employing alum—Baiseley's and Springfield filter plants. The two latter are no longer used for bacterial purification of surface waters. In fact, the Hempstead filter plant is the only one at present available for the original use.

AERATING WATER CHARGED WITH IRON BY FLOWING IT DOWN ZIGZAG TROUGHS

IRON REMOVED

The two mechanical plants have been used during recent years to remove iron from the well water pumped at the Jamaica and Springfield pumping stations, respectively. Alum is not employed, merely sedimentation and rapid filtration. During the last period that they were in operation, the early part of 1917, the efficiency of the former plant was 96 per cent, reducing 10.20 to 0.36 parts per million iron, and of the latter plant 99 per cent, removing 11.00 to 0.13 parts per million iron. In addition to the city plants the efficiency of iron removal is watched at the two plants of the Queens County Water Company at Valley Stream and at Rockaway Park, and also of the plant of the Broad Channel Corporation. The former plant is a slow-sand filter, and the two latter are of the mechanical type. During 1918 the Valley Stream plant removed 95 per cent of the iron (2.35 to 0.11 parts per million), the Rockaway Park plant 98 per cent (24.60 to 0.47 parts per million iron) and the Broad Channel plant 96 per cent (10.80 to 0.43 parts per million iron). It is essential for iron removal to adequately aerate and splash to remove carbonic acid. Ripening of the sand by films of iron oxide is essential, for perfect results, to complete the oxidation of the iron since the iron in solution is in ferrous condition and must become ferric to render it insoluble.

A COLLECTION OF CORE-SECTIONS

There are 44,731 linear feet of cores preserved for reference in the Municipal Building

CHEMICAL MUTATION

INTEREST in the alchemy of the Middle Ages seems to have been revived by the claims of recent inventors as well as by modern theories based upon new theories of radioactivity and observations that helium is an element which in time results from the breaking down of the other element, radium. The American Chemical Society News Service reporting a recent address by Dr. Ira Remsen points out that Sir William Ramsey was always interested in the possibility of changing one element into another and believed that upon one occasion he obtained a trace of lithium from copper although the result was never confirmed. More and more scientists are coming to the belief that the various elements as now known may after all be composed of various combinations of very much fewer kinds of matter and the dream of the alchemist, according to Dr. Remsen, may some day be realized. He says:

"It took centuries of effort to convince chemists that the claims of alchemists were without foundation. But the chemical profession went to the other extreme and held that the change of one element into another is impossible. The whole question is an open one, and this has come about through the work of Sir William Ramsey on radium. It is probable that many workers will experiment in this field, and it is fair to predict that some time someone will succeed. Whether it will ever be possible to transform silver or any other metals into gold, no one can say. In any case the subject is well worth investigating, and it is obvious that we shall never know the outcome without a great deal of careful research."

Molten Tungsten*

New Developments in the Manufacture of Tungsten and Its Compounds

By Hugo Lohmann

For the past few years, owing to the development of electric lighting and to the progress made in the manufacture of various alloy steels, whose importance and usefulness both from the industrial and military standpoint are of the highest significance, the various large electrical and metallurgical companies both in America and in Europe have been striving to solve the problem, which is beset with so many technical difficulties, of fusing tungsten and the other metals whose melting points are very high so as to be able to work with them in large quantities as one does with iron or steel. The problem has been one of plant scale operation only, as it is possible to melt the metal in small amounts in the laboratory. In making the tungsten filament for incandescent electric lamps, the metal is sintered. In manufacturing the powdered tungsten for use in alloying steel, chemical processes of precipitating the metal from the solutions of its salts are used. The properties, which this metal bestows on the steels that are alloyed with it are well known. We naturally are very much interested in learning what properties tools and machine parts made entirely from this metal would possess. We have been unable to do this up to the present time, because it has been impossible to melt the metal on a plant scale operation. The author of this article professes to have perfected a method by which this can be accomplished. He also suggests a method of producing a substance whose hardness is greater than that of the diamond.—Editor.

After it had been ascertained that the diamond was merely a form of crystallized carbon, which could be obtained by the combined action of high temperature and high pressure, the next step was to build furnaces in which these two conditions could be realized. Due to the labors of the famous French chemist, Moissan, an electric furnace was developed in which Moissan succeeded in synthesizing the diamond. Before Moissan's time the highest temperature procurable in the electric furnace was from 1,500 to 1,600 deg. cent. only. The furnace that Moissan used developed a temperature of 2,000 deg. cent., due to the use of a blast of oxygen. The first industrial application of the furnace was in the melting of platinum, which was effected in a limestone crucible at a temperature of 1,775 deg. cent.

The furnace designed by Moissan gave a highest theoretically attainable temperature of 3,500 deg. cent. The inventor did not limit himself to experiments with the diamond only, but investigated the melting points of a whole series of metals such as chromium, titanium, molybdenum, vanadium, boron, zirconium, tungsten and uranium. Moissan was the first to melt tungsten and deserves a great deal of credit for this achievement, but his experiments were conducted in very small crucibles which were only half a millimeter in diameter. The quantities of metal obtained thus are of course of no industrial importance whatever. However, enough of the molten metal was procured so that its properties could be studied both from the physical and chemical standpoint. Moissan also made tungstic carbide, whose formula is CW_2, in his furnace and investigated its properties. He noted that the pure tungsten metal obtained in this way could be polished, forged, cementated easily and possessed no action on the magnetic needle. (For further information on Moissan's work, see *The Electric Furnace* by Henri Moissan and *Comptes Rendues*, Vol. CVI, p. 1,225.)

Moissan suggested that it was possible to produce crude tungsten in large quantities in the electric furnace and that the crude metal could then be purified by melting it with an excess of tungstic acid, but he did not press the matter any further. He was eminently the pathfinder. The chemical and electrical industries, however, soon came to appreciate the advantages that these high melting-point metals possessed, especially the metal tungsten, which melts at 3,000 deg. cent.

To many it appeared that the only way in which such a high temperature could be obtained was with the aid of the electric furnace. There is however another means of obtaining high temperatures, viz., by the use of the aluminothermic method, which consists in reducing metals from their oxides by means of aluminum. The temperature that is procured in this way approaches that of the electric arc. In the years 1911, 1912 and 1913 the author succeeded in obtaining temperatures exceeding that of the electric arc by the aid of an especially constructed furnace. At the same time he was able to eliminate the principal disadvantage of the arc type of furnace, viz., the smallness of the source of heat and the space within which it is able to prevail. In this manner a furnace was constructed in which such large quantities of heat were evolved that it became possible to melt tungsten in large amounts, even in the form of the carbide, and, accordingly, it was possible to use the metal in making various articles of industrial importance. The author was able to liquefy 5 kilograms or about 12 pounds of amorphous tungsten in his furnace within 15 minutes and to obtain therefrom a thoroughly fused carbide.

Besides the possibility of producing any desirable quantity of molten metal or carbide and of using the same for various industrial purposes which was afforded by this apparatus, the furnace, in addition thereto, possesses certain important technical and economic advantages. The consumption of the current in the furnace is almost equal to the theoretical amount of energy required by the process. After the carbide of tungsten was successfully prepared in this apparatus, the carbides of all the other high melting-point metals such titanium, vanadium, zirconium, silicon, boron, uranium, etc., were also produced in commercial quantities.

The next step, after the commercial manufacture of tungstic carbide had become a *fait accompli*, was to produce the metal tungsten itself in the pure state free from carbon. The author succeeded in solving this problem by combining the aluminothermic reaction with the electric arc furnace. (The author hesitates to disclose the exact details of this apparatus, but promises a more comprehensive article in the near future.) While the idea itself was very simple, the practical application proved to be fraught with many technical difficulties. The aluminothermic reaction takes place with great volence, and the heat, that is generated, is evolved in a very short space of time, which makes it an extremely difficult matter to control and to guide the same into the proper channels, so as to make it accomplish what is required of it. It took several years of patient experimentation before a method was devised whereby

*Translated from *Elektrochemisches Zeitung*, 26, 29-33.

it was possible to mitigate the vigor of the reaction so that the heat evolved therein could be used in conjunction with that of the arc furnace to produce very high temperatures at which pure metallic tungsten, etc., could be manufactured. Inasmuch as the reduction of the metal from its oxide was affected by means of the aluminum, it was no longer necessary to use carbonaceous matter for this purpose and a carbon-free product was obtained. This is a point of great technical significance as the presence of carbon in the metal destroys some of its most valuable properties.

The extremely high temperature in the aluminothermic arc furnace necessitates the use of graphite in the construction of the crucibles, as this is the only substance that is refractory enough to withstand the action of the tremendous heat. The highly reducing effect of the liquid metal on the sides of the crucible is counteracted by suitable means (probably by the formation of an oxidizing atmosphere within the reaction chamber), so that the final product does not contact with any carbon.

THE PROPERTIES AND USES OF TUNGSTIC CARBIDE

Tungstic carbide possesses a hardness of 9.8 on the Moss scale. Hence, it is but little removed from the diamond, which is 10. It can replace the diamond entirely for all industrial purposes where the variety of this precious stone, known as bort, is used. It has been possible to make articles from tungstic carbide which are strong, compact and elastic enough so that they do not crumble away under use. This compound has been used to make the dies for wire drawing machines. Various cutting tools, facings for stone cutting machines and boring apparatus for oil and water wells and other purposes have been made from tungstic carbide. The results that have been obtained have been so excellent that there is no question at all that the carbide can supplant the industrial diamond in all its applications and that the manufacture of synthetic bort is altogether an unnecessary industry. The one great advantage of this new substance is that it can be made into any form that may be desired and that the cutting surface may be shaped so as to give the best results, while in the case of the bort we are limited to the crystalline form in which it is found in nature. A commercial advantage lies in the fact that the industry is not subject to the production of the diamond mines and to the price variations in the diamond market.

THE PROPERTIES AND USES OF THE METAL TUNGSTEN

The possibility of melting tungsten, of being able to pour it into molds and make with it all sorts of castings, of being able to forge it, roll it and cementate it has opened up the entire chemical, metallurgical and electrical field to this metal. It has been found that when the electric light filaments are made from the molten tungsten by drawing out wires of fine diameter, the candlepower of the lights is greater and the consumption of current per candlepower is less than in the ordinary sintered filament. Furthermore, the great hardness, high mechanical strength, high elasticity, great toughness and durability and extreme resistivity to high temperatures of the cast or forged metal render it very useful for various industrial and military purposes. We all know the remarkable properties of tungsten steel and the use of the pure tungsten metal, free from all contamination by carbon, for the same purposes gives results that are still more remarkable The author has professed to have made all sorts of high speed cutting and lathe tools with the metal and to have used the same with most extraordinary success. It can be readily understood that the cutting edge of the tool would stand up very well under the heat produced in the course of the cutting operation in the lathe, because of the very high melting-point of the metal. It was also found that the metal could be tempered very successfully. In fine, it is the metal par excellence for all work where great hardness is required and where the tool or machine part is subjected to great wear and high temperatures produced by frictional resistance.

The military importance of the metal has been mentioned and has been recognized as of the highest significance. The great guns that are used in naval armaments, in coast defense and in siege operations are all lined with tungsten steel. The reason for this is that the shell in its passage through the bore of the gun, after it has been fired, generates a great amount of heat due to the frictional resistance between the shell and the bore. Steel, alloyed with tungsten, withstands this heat best of all the alloys, but even then, after a certain number of shots have been fired, the gun must be relined for the high temperature has affected the surface of the bore so that it is no longer true and the shell, on leaving the gun, is no longer directed so as to reach its mark, as indicated by the position in which the gun has been pointed by the marksman. The expense of such relining is very great and the outcome of a misdirected shot in the heat of battle, because of a defective gun, may be very vital to its final outcome.

From what has been said above it is evident that the metal tungsten possesses properties which fit it for use in lining guns better than any other known substance. If it can really be melted in large quantities and worked in the same manner as the alloy steel is worked then there is no reason why the linings cannot be made from it.

THE PRODUCTION PROPERTIES AND USES OF URANIUM

The author has succeeded in preparing the metal uranium in the same way as tungsten. Uranium melts at 3,500 deg. cent. and possesses the highest atomic weight of all the metals, viz., 238.5. In X-ray work it has been known for a long time that the effectiveness of the X-ray tube varies directly as the atomic weight of the metal, from which the mirror is made, which is placed at the focal point of the kathode rays. Platinum has been used for this purpose. It is evident that the metal uranium would be better suited for this purpose because of its high atomic weight. The author was able to verify this fact by actually making X-ray tubes with uranium mirrors.

A further use of uranium is found in electrical technology in its substitution for platinum in making contact points for the spark plugs of gas engines, in making lamina and instead of platinum in the small piece of wire that is used to make contact through the glass part that holds the filament in the electric light.

The author has also been able to produce the difficultly fusible metal titanium in large enough quantities to render it possible to use the same for all industrial purposes.

A SUBSTANCE HARDER THAN THE DIAMOND

As is well known, the diamond is the hardest substance known. The diamond is crystallized carbon and the only substances that approach it in hardness are the carbides of the high melting-point metals such as tungstic carbide, silicon carbide, etc. In each it is noticed that the hardness is obtained by the addition of carbon. The question arises, is it possible to make a substance that is harder than the diamond?

It is known that every metal when it does not contain any carbon no matter how hard it may be is malleable at a certain temperature and consequently can be forged or rolled. In the forging or rolling process the position of the molecule is changed so that the structure of the metal becomes more compact and the so-called fibrous structure is obtained. This results in the production of a harder metal.

If we have, to start with, a substance that contains no free carbon and that possesses a hardness very close to that of the diamond then naturally, when this substance is subjected to rolling or forging, its hardness must be increased. We know that tungstic carbide has a hardness of 9.8 and does not contain any free carbon. The addition of carbon to it will increase its hardness as will rolling or forging it and the experiments that have been instituted in this direction will undoubtedly yield a substance whose hardness will surpass that of the diamond.

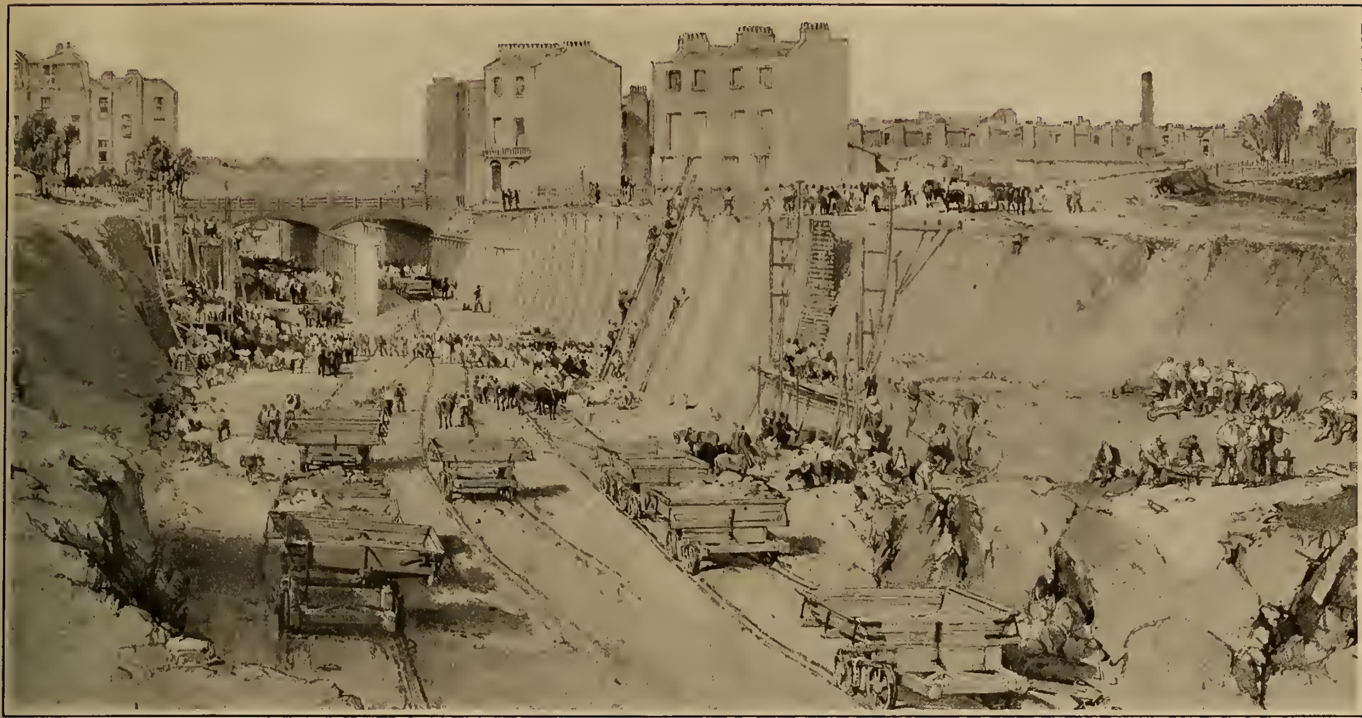


FIG. 1. BUILDING RETAINING WALLS, PARK STREET, CAMDEN TOWN, SEPTEMBER 17, 1836

Early Railroad Engineering

The London and Birmingham Railway—A Story of Its Difficulties, Failures and Success

By Herbert T. Walker

Illustrated from contemporary prints

LORD MACAULAY once said that "of all inventions, the alphabet and the printing press alone excepted, those inventions which abridge distance have done most for the civilization of our species."

At the present day, when railways are so far a necessity of our lives that without them existence would soon become impossible, it would be idle to discuss the truth of the proposition above quoted; but to the reflective mind it is profitable to look back and note the steps by which our gigantic system of transportation has been developed since the days of the Brunels and the Stephensons and the few far-seeing business men who supported them.

The London and Birmingham Railway was a representative pioneer railroad, for it was the first main line to enter London. It was antedated by other short lines within the metropolitan area, but in national and historical importance they were not in the same class as the railroad forming the subject of the present article, and it is thought that some notes, illustrated from a few old and rare lithographs by Bourne, will be of interest and value.

The London and Birmingham Railway was closely associated with the Liverpool and Manchester Railway which is known as "the great experimental railway of the world"; this for the reason that in its construction and working, principles were evolved and practice laid down which have formed railway engineering precedents from that day to this. Furthermore, both lines were designed and constructed by George and Robert Stephenson, whose names will always stand at the head of the list of our greatest engineers. And, lastly, the London and Birmingham and the Liverpool and Manchester lines now form a part of the great London and Northwestern Railway, which is one of the most highly organized and efficiently managed systems of transportation in the world. It has been called the "Pennsylvania Railroad" of Great Britain.

It is now difficult for us to understand the opposition to railways in the early days. Vast sums were spent to defeat the schemes in Parliament. The most eminent Parliamentary lawyers were retained by wealthy opponents to examine and brow-beat the promoters and their engineers. The landed aristocracy, together with the canal and stage coach proprietors, engaged scientific men to demonstrate, with the aid of mathematics, that railways were chimerical and that a locomotive engine could not travel faster than eight miles an hour; and when George Stephenson affirmed that a speed of fifteen miles an hour was entirely practical, he was greeted with shouts of derisive laughter, and his sanity was seriously questioned. When the charter for the Liverpool and Manchester Railway was finally granted, and before a stroke of practical work had been done, the legal expenses alone amounted to £27,000. After stupendous construction difficulties had been overcome, the road was opened in 1830. The success of this railway was brought about by Stephenson's locomotive engine "Rocket," which won the prize at the great Rainhill contest in 1829. This engine possessed all the essential parts of the modern locomotive, but we may not discuss this matter here, except to emphasize a fact which must not be forgotten, namely, that this historic engine, which is now in the Victoria and Albert Museum, London, was the cause of a change in the economics of civilization, the magnitude of which cannot be overestimated.

The first week's business established the success of the Liverpool and Manchester Railway beyond question. The company expected to earn £10,000 a year from passenger

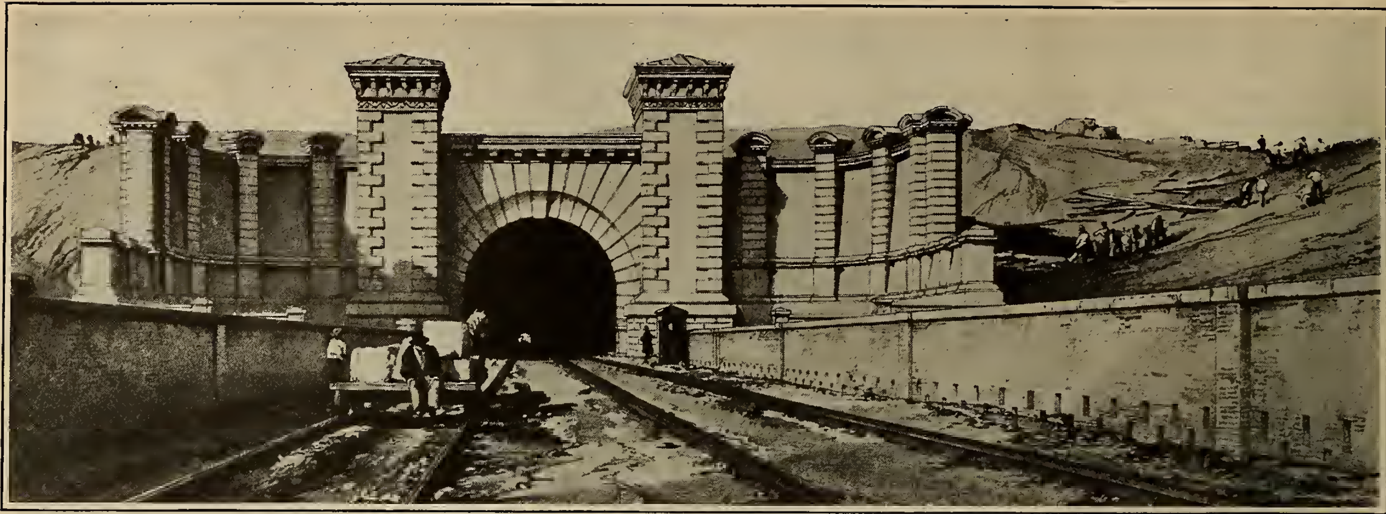


FIG. 2. TUNNEL UNDER PRIMROSE HILL. THIS TUNNEL WAS THE SUBJECT OF A MEDICAL EXAMINATION FEB. 20, 1837

traffic. The first year's receipts were £101,829. Freight was expected to give £50,000. It gave over £80,000. There was then a "boom" in railways, and capitalists began to think that there was money in this new field of enterprise. The Stephensons, father and son, quickly became popular, and were overwhelmed with applications for their services to construct new railways. The commercial classes soon became eager for a participation in the very thing which they had formerly derided, and, among numerous projects, the proposal to connect the great manufacturing city of Birmingham with the metropolis was now considered practical.

Before going further, we must note that the first idea of this railroad was brought forward in 1825, but was abandoned; and another introduced to Parliament in 1826 was thrown out. A third scheme was similarly treated in 1830; but the opening of the Liverpool and Manchester line gave a stimulus to railway projection, and a bill for the construction of a line between Camden Town and Birmingham was presented to Parliament. It passed the Commons, but was thrown out by the Lords in 1832. It was again brought forward in the following year and received the Royal assent on May 6, 1833.

George Stephenson was offered the appointment of chief engineer, but for various reasons he declined it, and the directors then decided to invite his son to fill the position. Robert, who was then 27 years of age, accepted the appointment with the understanding that his father would coöperate with him as consulting engineer.

At that time Camden Town, where Charles Dickens lived when he was a boy, was a remote suburb of London, and it was subsequently deemed advisable to extend the line to a more central position near Euston Square, the present terminus of the London and Northwestern Railway. Permission was obtained for this in 1834, which made the distance from London to Birmingham 112½ miles.

In all undertakings there is more or less difficulty in making a start, and it is now almost impossible to form an adequate idea of the mental and physical strain under which the early engineers accomplished their (to them) gigantic tasks. They worked literally day and night, and were nothing if not original. The engineer of today has his material made to order. Much of it is ready-made. Structural steel may be bought by the train load. All that is needed is to get out specifications and the material cut to dimensions is delivered on the ground. Engines, boilers and special machinery for every class of work are in the market for sale. The modern engineer cannot scheme anything that cannot be made. On the other hand, Brunel built bridges of absolutely original design and both he and his contemporaries, the Stephensons, while developing new ideas, were constantly asking themselves whether that which they wanted could be made. Could a truss be built to support loads hitherto unheard of? Could a cylinder of a given size be cast? If so, could it be bored to a uniform diameter for its entire length? Could a boiler be made to stand a pressure of 90 pounds per square inch when 75 pounds was considered dangerous? The foundryman, the machinest and the boiler maker would answer "No" to each question. Workmen were dull and slow, and the early engineers had to pull off their coats and show their men how to make things. Brunel and Gooch spent one Christmas day in a blacksmith's ship forging an experimental exhaust steam nozzle for locomotives.

Lathes had no tool rests and the tool was fixed in a ponderous iron bar, planted on the ground, steadied by the workman's foot, and held to position by the operator's physical strength. Milling cutters were unknown, and planing machines scarcely more so. Some of the old locomotives were made in blacksmith shops.

In the midst of all these distractions the opposition of the land owners had to be coped with. Public meetings were held in all the counties through which the line would pass, the project was denounced and strong resolutions were recorded against it. Although Robert Stephenson was weighed down by a multitude of cares, he was ordered by the directors to interview some of the more obdurate enemies of the railway in the hope that a call from "our eminent engineer" would placate them, but he was seldom successful. In describing one of these visits he said "We called upon Sir Astley Cooper, the eminent surgeon, in the hope of overcoming his aversion to the railway. His country house at Berkhamsted was situated near the intended line which passed through a part of his property. We found a courtly, fine-looking, old gentleman of very stately manners, who received us kindly and heard all we had to say." Sir Astley finally dismissed Stephenson and his companions with these words, "Your scheme is preposterous in the extreme. It is of so extravagant a character as to be positively absurd. Then look at the recklesness of your proceedings! You are proposing to cut up our estates in all directions for the purpose of making an unnecessary road. Do you think for one moment of the destruction of the property involved? Why, gentlemen, if this sort of thing be permitted to go on, you will, in a very few years, *destroy the noblesse!*"

New troubles came when a survey of the line was attempted. The land owners were vigilant and posted their servants, sometimes game keepers with shotguns, to obstruct the surveyors, and some of the levels were taken at night by means of dark lanterns. The London property owners were nearly as troublesome, for at that time the vicinity of Euston Square was a fashionable quarter, and the residents would not allow the surveyors to enter their back gardens or mount the roofs of their outbuildings. By various subter-

tuges, more or less amusing and sometimes dangerous, a survey of the whole line was at last completed, and in the course of his duties Robert Stephenson walked the whole distance between London and Birmingham upward of twenty times.

Settlement with the land owners was ultimately arrived at, they agreeing to accept £750,000 as compensation for their property that had been originally estimated at £250,000. The total expense of carrying the Bill through Parliament was no less than £72,868.

Ground was broken in 1834 and eighty miles of the line were shortly under construction, when further difficulties for the engineers quickly developed.

The works were let to contractors who were, for the most part, new to such business. Tools and machinery were imperfect and nearly everything was done by hand. There was no system of economizing time. Every one from the chief engineer down to the pick and shovel man had much to learn. The plans called for a double track road with easy grades, the maximum being 1 in 330 (except the Camden Town incline) for the tractive power of the old locomotives was very low; consequently, miles of deep excavation had to be carried on in order to form a level road from valley to valley through the intervening ridges, and there were many tunnels. Here, however, Robert Stephenson's experience in the coal mines rendered him good service; but even he, with all his practical knowledge, could not foresee the serious obstacles which confronted him in quick succession.

All the estimates were too low. Thus, the estimate for rails and their accessories was £213,000; they cost £460,000. Instead of wooden ties, the rails were laid on stone blocks costing £180,000. These were a dead failure, and after a short trial were replaced by wooden ties. It is interesting to recall that the locomotive is an offshoot of the stationary engine, and, as the latter was always built on a stone foundation, so, by the persistency of the human mind, it was thought that the locomotive engine required support on similar material.

Details of all the construction work of this unique railroad cannot be given here, so we will briefly describe some of the more important, beginning at the London end.

The aristocratic residents of Euston Square and Regents Park objected to locomotives, and it was therefore decided to haul the trains from Euston to Camden Town by cable traction. Two stationary engines of 60 horsepower each were built underground where the railroad crossed the Regents Canal, about a mile from the Euston terminus. Each engine moved an endless rope 7 inches in circumference and about 13 tons in weight. The ropes ran over pulleys placed in the center of the two tracks for trains coming from Euston, the up-grade being 1 in 60 and 1 in 75. On arriving at Camden Town, the trains were taken on by locomotives. Incoming trains ran into Euston by gravity. When the cable system was put to work, the residents made a further objection to the noise caused by the rattling of the ropes and pulleys.

Fig. 1 shows the line in course of construction September 17, 1836. The bridge is under Park Street, Camden Town, about three-fourths of a mile from Euston Square. Just beyond the bridge is a view of the open country toward Chalk Farm, where the first sod was cut June 1, 1834. The whole of this region and for many miles beyond is now a densely populated quarter of London. Note the primitive dumping wagons drawn by horses and the absence of all the mechanical appliances now commonly used for such work. The retaining walls were of brick with concrete backing, and were built with curved outlines obtained by the use of the batter frames as shown. The walls were a splendid piece of work, but the wet clay soil subsequently gave trouble, and transverse overhead girders had to be laid between them to keep them apart. It will be noticed that the excavation is for a four-track road. The reason for this was that the directors of the Great Western Railway proposed to connect with the London and Birmingham Company's line at Kensal Green, about four miles from Euston, which was to have been a joint terminus for the two roads. The plan was abandoned by reason of a dispute between the two companies as to their respective rights of using the tracks. The Great Western Company then acquired the necessary land and diverted their line from Kensal Green to Paddington at the west end of London. This left the London and Birmingham Company with a four-track road from Camden Town to Euston which they had no use for until many years afterward.

A few blocks south of the scene pictured in Fig. 1 the rail-

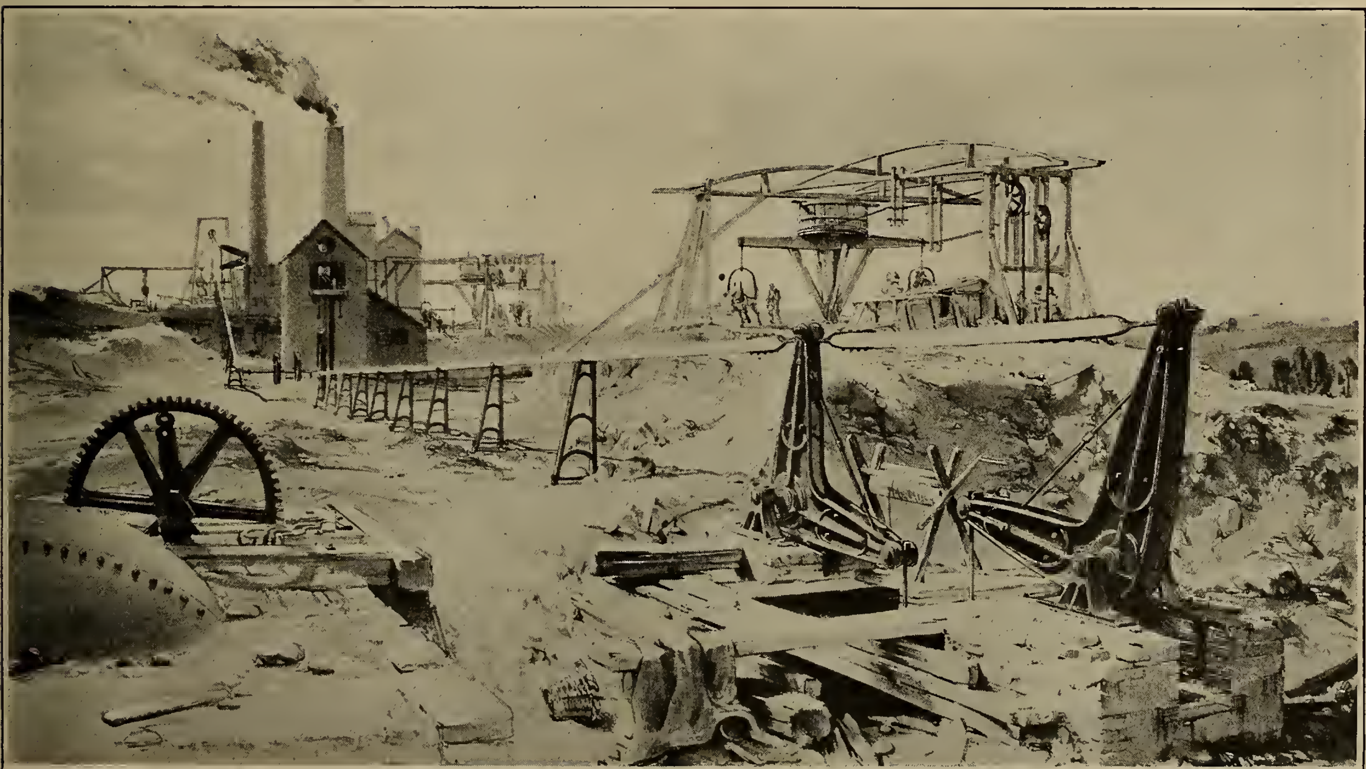


FIG. 3. PUMPING MACHINERY FOR DRAINING THE KILSBY TUNNEL

FIG. 4. BERKHAMSTED CUTTING JUNE 10, 1837, SHOWING ONE OF STEPHENSON'S CONSTRUCTION TRAINS

road passes under the Hampstead Road, near which was the "Wellington House Academy" where Charles Dickens went to school in 1825. It was partly demolished by the railroad, and, quoting Dickens's words "had its school room sliced away by the Birmingham Railway when that change came about." Dickens took much interest in this railroad and in the sixth chapter of "Dombey and Son" he gives a description of the neighborhood between Euston and Chalk Farm and the state of chaos into which it was thrown by the construction work of which our illustration gives but a faint idea.

The next important work was the Primrose Hill Tunnel, the handsome portal of which is illustrated in Fig. 2. It passes through the stiff London clay which was close, compact and dry—more difficult to work than stone itself. The clay was entirely free from water, but its absorbing properties were such that when exposed to the air, it swelled rapidly. Stephenson informed Samuel Smiles that the pressure behind the brick work was so great that it made the face of the bricks to fly off in minute chips, which covered the engineer's clothes while he was inspecting the work. It was finished without accident. To illustrate the primitive way of moving construction material, attention is called to the small flat car carrying a few blocks of stone and drawn by one horse.

This tunnel gained some notoriety as a subject for medical examination, which is amusing to us now, when subterranean travel is a part of our every-day lives. One of the many weapons in the hands of opponents of railways was the awful danger of traveling underground. Aside from the risk, medical gentlemen were strongly of the opinion that these noisome caverns would produce a train of diseases and shock to the nervous system, especially dangerous to ladies in a delicate state of health. To combat this prejudice, the railway directors arranged for a visit of experts in a special train to the tunnel on February 20, 1837. The party consisted of doctors of medicine and lecturers on chemistry. After a careful examination, their report, in part, was as follows: "We found the atmosphere of the tunnel dry, of an agreeable temperature and free from smell. The lamps in the carriage were lighted and in our transit inward and back the sensation experienced was precisely that of traveling in a coach by night between the walls of a narrow street. We are decidedly of opinion that the dangers incurred in passing through well-constructed tunnels are no greater than those incurred in ordinary traveling upon a turnpike road, and that the apprehensions which have been expressed, that such tunnels are likely to prove detrimental to the health or inconvenient to the feelings of those who may go through them are perfectly futile and groundless."

One cannot avoid the impression that this sudden and complete change of opinion on the part of the scientists was induced by favorable conditions, physical or otherwise, "arranged" by the directors.

There were eight tunnels between London and Birmingham, but we have space to notice only one more. It presented difficulties that would be serious to modern engineers, but to the men of the early thirties they were well-nigh insurmountable, and were conquered only by British tenacity and perseverance. This tunnel is at Kilsby, about 80 miles from London, and is 2,423 yards long, running at an average depth of 160 feet below the surface. Previous to letting the contract, trial shafts were sunk which indicated that the ground consisted of shale of the lower oolite, and the work was let accordingly. Soon after starting, it was discovered that between the two trial shafts, about 200 yards from the south end of the tunnel, there existed an extensive quicksand under a bed of clay 40 feet thick, which the borings had escaped in a most singular manner. At the bottom of one of these shafts the excavation and building of the tunnel were proceeding, when the roof suddenly gave way, a deluge of water burst in, and the workmen with the utmost difficulty escaped with their lives. They were only saved by means of a raft on which they were towed by one of the engineers, swimming with a rope in his mouth to the lower end of the shaft, out of which they were safely lifted to the daylight.

The work was immediately stopped; and the contractor who had undertaken the job, though he was relieved by the company from his engagement, took to his bed and soon after died.

As the pumping engines were not powerful enough to make any impression on the water, the question arose whether the works should be proceeded with or abandoned. Robert Stephenson sent for his father and the two took serious counsel together. George was in favor of pumping out the water from the top by engines erected over each and every shaft. Robert concurred in that view, but other engineers pronounced the plan impracticable and advised the abandonment of the enterprise. The directors nevertheless decided to go on, and the largest steam pumps available were then ordered. In the mean time Robert conceived the idea of running a shaft along the heading from the south end of the tunnel, with a view of draining off the water, and the drift was proceeded with immediately. When the excavators had nearly reached the quicksand there was a sudden roar as of distant thunder. It

was hoped that the water had burst in and the sand bed would thus drain itself off. Instead of which very little water appeard, and on examining the inner end of the drift, it was found that the loud noise had been caused by the sudden discharge into it of an immense mass of sand, which had completely choked up the passage, preventing the water from draining off. Numerous additional shafts were then sunk over the line of the tunnel, at the points where it crossed the quicksand, and the engines were erected and put to work.

Fig. 3 shows how these pumps were operated by means of transmission rods supported by numerous reciprocating arms. The rods were connected to bell crank levers operating the pumps below, and were driven by engines erected in houses at a distance. There were twelve steam engines operating pumps in eighteen shafts, and they pumped day and night for eight months before the water began to abate. The excavated soil was brought to the surface by horse whims, each one consisting mainly of a large drum, winding and unwinding a rope simultaneously, so that as a loaded bucket was drawn up an empty one was lowered alternately. Two of these whims are shown in the illustration.

Thirteen hundred workmen then proceeded with the building of the tunnel at several points. Every one labored constantly. The eight-hour day had not then been thought of, and men took a real interest in their work. In times of emergency they would toil for twelve and even sixteen hours, with only short intervals for meals. It often happened that the bricks were scarcely covered with cement, ready for the setting, before they were washed quite clean by the streams of water pouring from overhead.

The original estimate for the Kilsby Tunnel was £99,000, but by the time it was finished it had cost over £300,000. Robert Stephenson reported that nearly all the contractors for the tunnels on this railway either failed or were helped through by the company.

The cuttings and embankments were little less heavy and difficult than the tunnels, but we may notice only three of them.

Twenty-eight miles from London was the village of Berkhamsted, its quiet beauties remaining undisturbed until certain trespassers came tramping over the fields and crashing through the woods. Some carried chains and others bore curious instruments mounted on tripods. This was a party of surveyors and engineers headed by Stephenson. In due time they were followed by an invading army of stalwart laborers with picks, shovels and wheelbarrows. These men had an insatiable thirst and, by the law of demand and supply, temporary beer houses were opened expressly for their accommodation. Prohibition was unknown. They made night hideous with singing, roaring and fighting. The village of Kilsby had a similar experience. When a gigantic trench had been cut through the beautiful woods and deer park a new horror made its appearance. This was a fiery steam engine on wheels, with a screaming whistle audible for miles around, and dragging forty strange looking wagons loaded with earth. No one had ever seen such a thing before, and farmers left their crops to gaze on it. Animals strongly objected to it; and whenever it came along horses and cows ran for their lives, followed by pigs squealing with terror. This was one of Stephenson's construction engines, and is shown in Fig. 4, reproduced from a sketch taken June 10, 1837, with a road bridge in course of building. Close to the railroad here was the residence of Sir Astley Cooper previously alluded to.

A noteworthy example of embankment is delineated in Fig. 5, sketched June 28, 1837, at Wolverton, 52 miles from London. Here the line traverses the valley of the Ouse at an average height of 48 feet. During the work difficulties from subsidence were encountered; and the view shows a wooden trestle built over one of the landslides. The contractor failed here, and the work had to be completed by the company, giving Robert Stephenson much anxiety. The ground was composed of blue clay lias, limestone, gravel and sand, and it gave way beneath the enormous weight. When filled up, it caught fire, for in its composition was a portion of alum shale, containing sulphuret of iron. The material decomposed and ignited by spontaneous combustion. We may readily imagine the consternation of the country folk at beholding a railway on fire.

Fig. 6 shows a view of the celebrated Blisworth cutting, 63 miles from London. This lithograph was published in 1839, after the road had been opened for traffic. The cutting is a mile and a half long and in some places 65 feet deep, passing through earth, stiff clay and hard rock. One-third of the cutting was stone, and beneath the stone lay a thick bed of clay under which were found beds of loose shale, so full of water that constant pumping was necessary during construction. After a year and a half of incessant labor, the contractor had to abandon his work. Robert Stephenson then took the job in hand for the company; two locomotives were put on, one at either end of the cutting, to haul away the excavated material. Eight hundred laborers were kept busy digging, wheeling and blasting. Twenty-five barrels of gun powder were exploded weekly, and by the time the blasting was finished three thousand barrels of powder had been used. The bed of rock which overlaid the clay had to be supported by retaining walls which had not been built when the picture was taken, but one of the temporary timber supports may be seen on the left. The bridge in the distance has a span of 63 feet and its abutments rest on the solid rock sides of the cutting. The stone blocks supporting the rails are clearly shown. As previously noted, they were a costly failure.

FIG. 5. FILLING IN A LANDSLIDE, WOLVERTON EMBANKMENT, JUNE 28, 1837

In the distance is a "mixed" train hauled by two of Stephenson's locomotives. The open freight cars are at the rear of the train. The original lithograph shows two men riding on the top of the last passenger coach. These are the "guards" in charge of the train. It also shows the passengers' baggage piled on the roofs of the coaches, but these details do not come out clearly in the half-tone cut. In the early days there were no baggage cars, hence the necessity of stacking passengers' luggage on the roof. Sometimes it fell off and was lost. At other times it was stolen in transit. The man standing by the track and holding a flag is a railway policeman. These men guarded the company's property, acted as signalmen, and were ready to assist the movement of trains. They had power to arrest trespassers, and a heavy fine was inflicted if any unauthorized person was caught walking on the track.

The first portion of the railway from London to Boxmoor, 24 miles, was opened in July, 1837, and in September, 1838, the line was opened throughout. From a copy of the original timetable it appears that the fastest train covered the distance from Euston to Birmingham in 5 hours 37 minutes. The present-day trains make the same run in 2½ hours.

We will now consider the rolling stock of this historic railroad. If we could see the engines and cars today they would look like toys. Fig. 7 shows the engine which hauled the first passenger train to Birmingham July 20, 1837. This locomotive weighed but 11 tons. The cylinders were 12 inches in diameter by 18 inches stroke. Driving wheels 5 feet 6 inches diameter. The boiler was lagged with wooden staves painted green and bound with bands of polished brass. The domed fire-box was covered with polished copper, giving the engine a bright and attractive appearance. The freight engines were of the same design, but weighed about 13 tons. Sometimes five engines were required to pull a long train. We may note in passing that many of our modern locomotives weigh over 200 tons.

FIG. 6. ROCK CUTTING AT BLISWORTH, 1839. RAILS LAID ON STONE BLOCKS

The first-class passenger cars were comfortable, but so small and niggardly in head room that an incautious entering passenger would strike his hat against the door lintel. The second-class cars had hard wooden seats and very small windows. The third-class cars were amazingly bad, and known as "open trucks"; for they were without roofs, and the unfortunate passengers were blinded by dust and cinders, choked in tunnels and some even died from exposure in cold or wet weather, as umbrellas could not be held up in the rushing wind. *Punch* said some good things about these cars, and one wag called them "pig boxes." The comparison was not inapt, for as animals were carried in open cars, about the only difference was that swine were not provided with seats as were the human passengers. Certainly, hogs in transit are better housed today, for they do have a roof over their heads. This shameful treatment of poor people unable to pay the higher fares, was a disgrace to England.

The objection to railway traveling by the richer classes was so great that the more opulent and exclusive patrons were, on payment of extra fees, allowed to ride in their own carriages carried on flat cars, called "carriage trucks." These cars had shallow sides, but the ends were open. The writer has seen some of these shortly before they were broken up, but the railroads discontinued them in the early fifties, as they were both dangerous and inconvenient.

Charles Dickens has described this way of traveling in "Dombey and Son," and it may be noted here that although Dickens was not an engineer nor a technical man of any sort, his keen insight and ability to describe what he saw, enabled him to accurately picture objects and appearances of which he had no professional knowledge. The ordinary reader would pass over these passages, but by technical men they are well understood and appreciated. This is one of the many examples of the marvelous powers of observation possessed by the great novelist.

If the reader will refer to "Dombey and Son," twentieth chapter, he will find a good description of the journey from London to Birmingham by Mr. Dombey and his friend, the redoubtable Major Bagstock. This trip was taken, not in a railway car as the average reader would suppose, but in Mr. Dombey's family chariot. The Major's Indian servant (commonly known as "The Native") had previously packed in the carriage all sorts of requirements for the journey and when all was ready Mr. Dombey and his military friend took their places inside with the Native and Towlinson (one of Dombey's servants) in the rumble behind. On arriving at Euston the occupants alighted and Dombey and the Major walked up and down the platform side by side. There was a working man near the engine who touched his cap every time they passed. The engine was of the same design as shown in Fig. 7, and the period of the story was about the year 1844 when the rope traction was superseded by locomotives. This man was Mr. Toodle, the fireman of the engine and, as his wife had been wet nurse to little Paul Dombey, lately deceased, the honest fellow thought that Mr. Dombey would favor him with a friendly word, and introduced himself as the man who would "have the honor of stokin' of your down, Sir." He was mistaken, and the merchant prince gave "this presumptious raker among coals with cinders in his whiskers" a curt dismissal.

We will now look at the rear end of the train and we find that in "the bustle of preparation at the railway" the horses have been unharnessed from Mr. Dombey's carriage and were probably taken care of by Towlinson. The railway porters then pushed the carriage up a ramp on to the flat car above described. The wheels were then blocked and fastened to the floor and two cross bars were bolted to the car's shallow sides, firmly bracing the front and rear wheels. These operations took time and the printed rules of the company prescribed that

"Carriages should be at the station a quarter of an hour before the time of departure." The porters then lined up, touching their caps in expectation of the usual tips, although by the aforesaid rules, gratuities were strictly forbidden, and the great merchant with his military friend entered their exclusive conveyance. The step of a road carriage was higher than that of a railway car and Dickens describes how the heavy Major was hoisted into the Dombey chariot by his servant. This long-suffering foreigner then resumed his seat in the rumble. The train was probably the "Fast Mail," leaving Euston at 9:30 A. M., arriving at Birmingham at 2:30 P. M. with an average speed of about 22½ miles per hour, with occasional spurts of 50 miles an hour on favorable grades. We may imagine this primitive express train, weighing between 40 and 50 tons. On the locomotive is Mr. Toodle with a piece of new crape round his oilskin cap in loving memory of little Paul. He is firing his engine with coke, as the local residents object to coal smoke. The little engine has all it can do to pull the train up the hill to Camden Town. On the last car of the train is Mr. Dombey's chariot, with the proud and silent owner abstractedly listening to the anecdotes of "tough old Joey B. Sir." The carriage being higher than a railway car the pitching and swaying are magnified. In fact, some people traveling this way suffered an attack of sea-sickness. Mr. Dombey would be far more comfortable in a railway car, but Dickens knew that the great man would never travel in a public conveyance. In the rumble is the unfortunate Native (currently believed to be a prince in his own country) exposed to the full force of wind, dust and cinders. When he gets into the Kilsby Tunnel he will be wet to the skin. Dickens observed this aqueous tunnel at a glance, thus—"A ray of light upon the wet wall shows its surface flying past like a fierce stream."

Although the locomotives were so small, their appearance at night was more impressive than that of modern engines, provided as these are, with closed ash pans under the fire-grates, and spark arresters. In chapter fifty-five of "Dombey and Son" we have a fine description of an express train at night: "A trembling of the ground; a distant shriek; a dull light advancing, quickly changed to two red eyes and a fierce fire dropping glowing coals; tracked through the distant valley by a glare of light and lurid smoke, and gone!"

The average reader, if he gave it any thought, would wonder how red lights could be seen on an approaching engine, as they are always placed at the back of the last car. The explanation is simple if we know that on some early railroads it was the practice with trains traveling at night on a single track to carry two red lamps on the front beam of the engine. One of these lamps appears in Fig. 7, which also shows at the bottom of the fire-box, the ends of the three cross bars for supporting the fire-grates. The violent motion of the engine would thus scatter the red hot fuel along the track. There were no spark arresters and the boilers were very short, so that at high speed the draft drew fire out of the chimney. If the locomotive burned coal, a dull red flame would appear. If the engine was a coke burner the flame would be of a ghastly blue color. Sometimes the base of the chimney got red hot. To remedy this defect, Stephenson designed his "long boiler engine" which is familiar to all students of the locomotive.

In looking back on the history of railway construction and working—of which the foregoing notes are a mere fragmentary sketch, we are compelled to admire the creative genius and indomitable perseverance of the men who originated and carried out the system of transportation which we are enjoying today. We may agree with John Bright, who in the course of a speech in the House of Commons said: "Who are the greatest men of the present age? Not your warriors, not your statemen; they are your engineers."

In 1846 the London and Birmingham was amalgamated with the Liverpool and Manchester and several other short lines under the title of the London and Northwestern Railway Company, and it was at this period that the great "Railway Mania" came to its height, for the reasons which will now be briefly described:

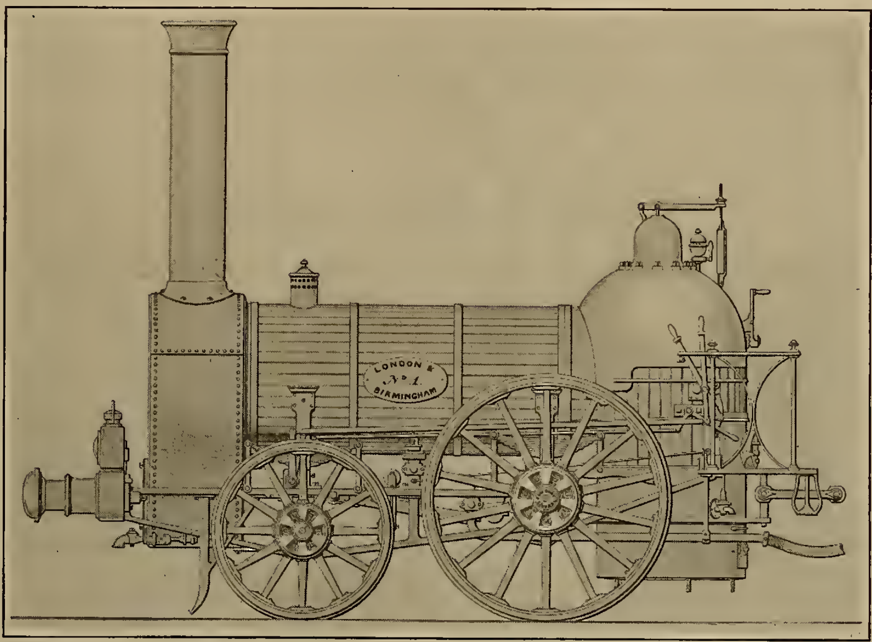


FIG. 7. FIRST PASSENGER LOCOMOTIVE, 1837

At this distance of time it is difficult to understand the wild enthusiasm of the public over railways, unless the mental eye is focused by some knowledge of the conditions which led up to it. Speaking generally, the birth of the railway was an event unparalleled in the history of the world. It is doubtful if anything like it will happen again. People were stunned by the new meass of travel. Clergymen complained that instead of attending church their people flocked to the railroad "to see the trains go by." Imagine the transition from a stage-coach jolting over rough roads at 10 miles an hour to a train rushing along a smooth track at 40 miles an hour or more! And this all within a year or two from the opening of the Liverpool and Manchester Railway. Again, the Liverpool and Manchester and the London and Birmingham lines paid dividends of 10 per cent. The Stockton and Darlington Railway paid 15 per cent. Money was cheap and remunerative, investments were scarce. With these facts in mind we begin to realize why people lost their mental balance, and capitalists, great and small, plunged recklessly into this new investment. The Stephensoss with George Hudson (the leading railway financier) were subjects of hero-worship; and kings esteemed it an honor to shake hands with them. The railway was recognized as "the greatest civilizer of the age." Railway pictures were sold in print shops. Cups and saucers were embellished with paintings of Stephenson's locomotives, and pocket handkerchiefs were similarly decorated. Tailors' shops exhibited trousers made of gray mixture cloth into which were woven parallel black lines in groups of four. This was "The Railway Pattern" and very popular with the young men of the period. In concert rooms "The Railway Gallop" was a favorite number on the program. It was cleverly orchestrated and really effective. Starting very slowly, the speed and volume of sound with the constant beat

of the engine gradually increasing until it reached "50 miles an hour," with occasional long or short bursts of thunder from the drums to suggest tunnels and bridges. All this sounds childish today, but it was a very real thing in the early forties.

No railway scheme was too wild for investors, and contemporary prints show crowds of promoters with great rolls of plans under their arms, besieging the offices of the British Board of Trade. During the years 1844-5-6 no fewer than 440 bills were passed by Parliament authorizing the construction of 8,470 miles of railroads and the raising of new capital to the amounnt of £180,138,901. In contrast to the old Parliamentary opposition, bills were passed practically as presented. It is estimated that £100,000 per week was spent in advertising new lines, some of them running parallel with each other. When the advertisements appeared shares were instantly applied for, and in many cases large premiums were paid for the mere chance of allotment. Some of these competing lines were never built and others that were built never paid interest. Even a line from Paris to Pekin was considered a probability.

Some far-seeing men sought to discourage the craze by ridicule, but oɪ course without effect. A sarcastic writer proposed issuing a prospectus inviting subscriptions for "The Great North Pole Railway, forming a junction with the Equinoctial Line, with a branch to the Horizon." Another writer remarked that if such an advertisement was ever published subscriptions would, doubtless, be forthcoming. He was not far wrong, for the title of some of the projected lines were grotesque, embracing the names of towns and hamlets of absolutely no commercial value. *Punch* in 1846, published a prophetic railway map of England. It looks like a conglomeration of spiders' webs.

Wild schemes for the construction of 600 miles of railways in the county Lancashire alone at a cost of £15,000,000 sterling were advertised, and £1,250,000 were immediately subscribed. In every case lines of speculators were found in the street outside the promoters' offices, and the police were required to keep order. When the doors were opened there was a mad rush for position, and many fights ensued, during one of which the secretary's table was overturned and the clerks fled in terror.

A few level-headed financiers gave repeated warnings of the inevitable outcome of building unnecessary competing lines, but nobody heeded them. Vast sums of money disappeared and were never accounted for, and in due time came the crash, bringing ruin and misery on countless numbers of people.

For some of the notes embodied in the present article the writer is indebted to Smiles' "Lives of the Engineers." His thanks are due to Sir Gilbert H. Claughton, Bart., chairman of the London and Northwestern Railway Co., for courtesies extended, and the valuable assistance of Mr. W. B. Paley, the noted railway historian of London, is also gratefully acknowledged.

Centrifugal Casting

Various Methods of Forming Pipes and Tubes by Centrifugal Deposition

THE following abstracts from recent technical periodicals were gathered by *Mechanical Engineering* and published in the July, 1921, issue of that journal. They give an excellent review of recent progress in this interesting method of casting:

NON-FERROUS CASTINGS IN SPINNING MOLDS

Description of a method for casting copper bands for large Navy shells by a centrifugal casting machine process as used at the works of the George C. Clark Metal Products Company, Detroit.

The process appears to be one which requires a high grade of skill and knowledge at practically every stage, beginning with the handling of the metal, it would appear that positive methods must be employed that will permit the band to be cast at the most desirable temperature; as otherwise the physical properties of the compound will not be right.

The metal is cast in down-draft melting furnaces of 3,000-pound capacity each, and from the furnaces is poured into ladles of a capacity suffificient for three bands. It is hauled to the casting room by means of an overhead trolley system and extra precaution is taken that the metal does not oxidize on its way to the casting room.

The principal parts of the casting machine are the die and die holder, the movable spout and the metal-pouring attachment. The holder is made of plain carbon steel wire, the die or liner is a specially heat-treated forging. A hinged cover plate of the same diameter as the holder and having an opening large enough to accommodate the pouring spout is made to open and close on the side of the die and holder. It is said that the life of a liner is such that about 250 bands may be cast before it is burned out and replaced.

It is obvious that all revolving parts must be in absolute balance, as otherwise the band will not come out true. The metal is poured through the spout so arranged that it can move in and out of the die. Pouring is done by tilting the small crucible in the machine so that the metal will flow through the spout into the die. While the machine is still in motion the spout and crucible are pulled back out of the way and when the band shows the desired color for annealing, a stream of water is turned on the band. After the band has solidified sufficiently and has received the proper annealing, the water pipe is taken back out of the way, the cover plate is unscrewed and the band removed from the die. After the band is cast, it is necessary to keep the lip of the pouring spout clean, as a certain amount of metal clings to its side and has to be removed by hand with a chisel. The bands themselves are then machined.

It is stated that the most successful bands made are of the larger diameters, 10 inch and up, and that the percentage of rejected castings made by this process is small. Louis J. Josten in *The Iron Age*, Vol. 107, No. 20, May 19, 1921, pp. 1289-1292.

CENTRIFUGALLY CAST CAST-IRON PIPE

Description of the DeLavaud process of centrifugal casting of cast-iron pipe as carried on commercially in Canada.

The pipe is cast on the inside of a horizontal water-cooled rotating cylinder revolved on its axis by an impulse water-wheel integral with itself and flared at one end to give the proper contour to the bell. The mold revolves in a cylindrical stationary casing and is supported at two points in its length by two pairs of friction rollers which are carried on the inside of this casing. In the manufacture of 6-inch water pipe, the speed of revolution is about 550 r.p.m.

The molten metal is introduced into the mold by a cantilever spout, which receives its supply from a tilting ladle operated by hydraulic pressure. The iron for the bell end is first supplied, immediately following which the casing and mold are moved backward by hydraulic means on horizontal ways away from the ladle and spout, thus enabling the latter to supply the metal continuously from the body of the pipe right out to the spigot end. The mold continues to rotate for perhaps 15 seconds after the last of the necessary iron has been supplied.

As it comes from the mold the iron is chilled and must be annealed. This annealing in a special furnace takes from six to seven minutes, after which the pipes are allowed to cool in still air.

Centrifugally cast pipes are lighter than sand mold pipes of similar bore, and, for example, in 4 inch size the standard C class weighs 23.3 pounds per foot and the centrifugal pipe 15 pounds.

The metal in centrifugally cast piping is of a dense homogeneous character and the pipes are smooth inside and out. Tests were carried out by the writer at the University of Toronto on pipes and pipe material made by sand casting and spinning and it was found that roughly the tensile strength of specimens from centrifugally cast pipe was 2.3 times as great as that found for specimens cut from sand mold pipes. In every other test the centrifugal modulus of elasticity was 2.3 times greater for machine-made pipe than for ordinary pipe, and a 6-inch pipe with walls 0.28 inch thick was found capable of sustaining an internal hydrostatic pressure of 1,250 pounds per square inch without failure.

The pipe is manufactured in Canada by the National Iron Corporation, Ltd., Toronto.—Prof. Peter Gillespie, of the University of Toronto, in *The Canadian Engineer*, Vol. 40, No. 19, May 12, 1921, pp. 454-455.

STEEL TUBE CASTING

Description of a process for the centrifugal casting of pipe in which the metal is melted electrically in the same mold in which it is subjected to the spinning process.

The process is carried on in four stages, the first consisting of casting the metal in bars of approximately the same weight and length as the final tube. These bars, together with such additional metal as is necessary, are placed into the mold which consists essentially of an outside steel shell, a refractory lining and a graphite lining. The molds with the metal inside are closed air-tight at both ends and placed in a rack where electric current is supplied to the terminals from a bus-bar. They are left on the rack until the metal inside has thoroughly melted, and are then transferred to the spinning machine.

The spinning continues until the metal has solidified, the time varying with the kind of metal and to a certain extent with its external temperature. When the metal in the tube has set, it is allowed to cool until the contraction of the diameter of the tube is sufficient to pull it out of the mold. It is then subjected to such heat treatment as may be necessary.

The advantages claimed for this process are its practically automatic character permitting the use of unskilled labor, and, simultaneously, ability to control very strictly the temperature and combustion of the metal and also the absence of gases in the mold.—*The Iron Age*, Vol. 107, No. 20, May 19, 1921, p. 1300.

HUME CENTRIFUGALLY MADE CONCRETE PIPE

Description of a process for the manufacture of concrete pipe by centrifugal deposition as carried out by a company in South Africa.

The pipe is reinforced with steel and the first step in its manufacture is the preparation of the reinforcement. As the plant is located not far from the gold mine district of Witwatersrand, it is able to make use of the reinforcing elements of discarded mine haulage cables.

As the cables are delivered at the pipe works in coils, they are first degreased, which is necessary, as cement will not adhere to any material that has a greasy surface. The grease is burnt out by wood fire, the wire being somewhat annealed at the same time.

After the coil is cooled down it is unraveled with the help of specially designed motors. This is followed by spooling the cable, the spools being then transferred to the machine on which the reinforcement cylinders are made.

The spool of wire is placed on a spindle set vertically and fixed a few feet from the machine. The end of the wire is drawn forward and threaded through a series of three pulleys on a traveling feeder, these pulleys serving to keep the wire tight. The feeder itself is part of the reinforcement machine, along the base of which it is drawn by means of chains in a direction parallel with the cage core.

The reinforcement or "cage" is built on a round horizontal core consisting of four readily collapsible sections.

The molds are two-piece cylinders made of galvanized iron and are greased inside to prevent the cement from adhering. The reinforcement is then inserted and the end caps bolted in position. These end caps are broad, flat rings, the inside diameter of which is the inside diameter of the pipe to be made, the desired thickness of the pipe wall being exactly secured by the use of rings or end caps of the proper dimensions.

The pipe-making machines each make six pipes in one operation, the duration of which may be anywhere from 12 to 20 minutes, according to the size of the pipe.

In making the concrete for light-pressure pipe, Pretoria cement is used with sand and specially selected ¼ to ½ inch grit, in the proportion of 2 to 2 to 1; for high-pressure pipes sand and cement are used in the proportion of 2 to 1. The material is prepared in rotary mixers from which it is discharged into a pair of barrows traveling on a pair of rails underneath the pipe machines.

The speed of the pipe machine during the process of shoveling the concrete into the rotary molds is set slow and all the workman has to do is to throw the concrete rapidly, a shovelful at a time, into the mold. When the molds have received enough concrete the speed of the machine is increased (this speed varies with the size of the pipe and, for instance, for a 4-inch pipe, it is 360 r.p.m., while for a 6-foot pipe it is 48 r.p.m.).

One of the important features about the Hume pipe is the great denseness of the material. The following tests have been made to prove this. An ordinary 12-inch mold without reinforcement was filled with concrete and rammed in by hand as tightly as it would go. In other words, the same process was followed as one might use to make a solid concrete column. The mold was then placed on the machine and rotated at the speed required for the making of an ordinary Hume pipe. After that, the mass was examined and was found to have developed itself into a pipe with an internal diameter of 3½ inches, which would mean that the 12-inch column, as originally made, had a volume of air-filled spaces between particles equivalent to a pipe 3½ inches in diameter and that by the centrifugal action this was packed solid.

The pipe has also a rather unusual joint. The end of each pipe is so molded that instead of a flat surface a groove of a peculiar shape is produced, this groove being such that its deepest portion lies toward the inner periphery of the pipe while it becomes shallower as it reaches the outside periphery. When two pipes are brought together, their edges enclose a cone-shaped space, the apex of the cone being toward the outside of the pipe and this space is filled by the pipe layer with a special plastic compound.

A sleeve of concrete also goes over the joint and its inside diameter is a little larger than the outside diameter of the pipes. The annular space thus formed is filled with a mixture of sand and cement, which is caulked or rammed into position exactly as lead is used for joining iron and steel pipes. The practical effect of this system of jointing is that the greater the pressure of water in the pipes, the more resistant to leakage becomes the joint.

A claim is made that the Hume pipe never bursts and that when the pressure is increased beyond a certain point the pipe merely begins to "weep." If the pressure is further increased sprays of water appear, but there is no burst and not only that, but that when the water pressure is reduced to normal the pipe is just as efficient as it was before. In other words, the strain does not cause any deterioration.—*The South African Journal of Industries*, Vol. 4, No. 3, March-April, 1921, pp. 224-235.

The Super-Conductivity in Metals*

Experiments in Electric Conductivity at Low Temperatures by Kamerlingh-Onnes

By C. A. Crommelin

UPON various occasions it has been observed that the variation of the electrical resistance of metal wires differs greatly at high temperatures from the variation at low temperature. It frequently happens, *e.g.*, in the case of platinum that the temperature co-efficient diminishes sharply with a fall in temperature; at times a break has been found in the curve which represents the resistance as a function of temperature. Naturally, this observation aroused the question as to how electrical resistance would behave in the immediate vicinity of the absolute zero.

An opportunity to make investigations along this line presented itself to Kamerlingh Onnes at the University of Leyden, after he had succeeded in 1908 in liquifying helium and in almost attaining the so-called absolute zero, *i.e.*, minus 273 deg. cent. by the aid of this liquified gas.

Starting from the electron theory of electrical conductivity in metals Lord Kelvin came to the conclusion in 1902 that at the absolute zero the resistance must be infinitely great. His theory was that the degrees of dissociation of the electron would be nil at the absolute zero and that free electrons, in so far as they were still present would lose their power of motion, or, as Kamerlingh Onnes has expressed it, the electrons would condense like a vapor upon the metal atoms and freeze fast to them.

Up to that time it had not been found possible to confirm this theory by means of experiment. The minimum which was expected in the resistance curve was not found even at the temperature of liquid hydrogen (minus 253 deg. cent. to minus 259 deg. cent.). But with the help of liquid helium it became possible to carry on investigations in the immediate neighborhood of the absolute zero. At ordinary atmospheric pressure helium boils at about minus 269 deg. cent. and at a pressume of 3 mm. of the mercury column it boils at a temperature of minus 271.5 deg. cent.

The first experiments were made with a wire composed of pure platinum 0.1 mm. in thickness, whose resistance had already been determined at the lowest temperature of liquid hydrogen and which it was now attempted to find at the temperatures of liquid helium. The wire was wound upon a small glass cylinder, the ends being fused in the glass and soldered to long copper wires connected with a Wheatstone bridge. This coil of wire was placed in a glass vessel capable of being cooled by liquid helium. We will refrain here from giving a more exact description of this highly complicated apparatus, which we shall refer to merely as a cryostat and shall content ourselves with relating the results of the experiments thus made.

The results of even the first measurements made were highly surprising as is evident from the figures in accompanying table. In this table the temperatures are given in so-called *Kelvin* degrees, *i.e.*, they are counted upward from the absolute zero, 0 deg. cent. corresponding to 273 deg. K.

Thus we see that there is not a trace of the minimum which Lord Kelvin's observation had led us to expect—on the contrary, downwards from 4.3 deg. K. throughout the whole temperature range of the helium, there was exhibited a very slight and quite uniform resistance.

This entirely unexpected result suggested to Onnes that perhaps the resistance of perfectly pure platinum would be nil at the absolute zero and that the constant residual resistance observed might be caused by the traces of impurities which always cling to a platinum wire produced in the usual manner. In order to test the correctness of this idea the measured resistance of gold was graphically extrapolated in the helium range. This extrapolation made it appear very probable that the residual resistance does, indeed, proceed from impurities. The accuracy of this extrapolation was then tested by measurements at the helium temperature. It was found that the resistances of gold containing a known quantity of impurities likewise exhibited a residual resistance—and the greater the contact of foreign matter the greater this residual resistance. This leads us to believe that the resistance of both pure gold and pure platinum differ very little if at all from nil at very low temperatures. While this conclusion is not final it is very convincing to the effect that the above mentioned theory of Kelvin must be given up—indeed, the experiment proved most convincingly that there can be no question of an infinite increase in the resistance.

The investigation was next directed towards the experimental support of the concept of the becoming nil of the resistance in an absolutely pure metal. But unfortunately metal wires

Table 1

ABSOLUTE TEMPERATURE		$\frac{W_t}{W_o}$
273.09 deg. K		1.0
20.20	liquid H_2	0.0171
14.20	liquid H_2	0.0135
4.30	liquid H_e	0.0119
2.30	liquid H_e	0.0119
1.50	liquid H_e	0.0119

W_t = measured resistance.
W_o = resistance at 0 deg. cent.

of such absolute purity as required by the experiment could not readily be obtained since the very act of drawing them always contaminates them. It is possible, however, by distilling quicksilver in a vacuum to obtain it in much purer form than other metals; mercury was accordingly selected. It was placed in a capillary tube bent into a zig-zag form and having a diameter of about 0.005 mm. Ordinarily, when mercury is frozen its particles fall asunder. To prevent this a special device was employed, which consisted in attaching small mercury containers to the upper part of the capillary tube.

Now when the mercury wire is slowly cooled from bottom to top, the mercury container furnishes mercury as the mercury wire contracts and thus prevents the breaking of the thread of quick silver. In this manner it finally became possible, after many fruitless attempts to produce mercury resistances of sufficient magnitude to meet the demands of the experiment (*e.g.*, 172.7 Ohm at zero deg. cent.). But the enormous amount of trouble and labor which was required to accomplish this was richly rewarded by the results of the experiments thus made possible. The resistance proved to be immeasurably small at the temperature of helium; the most remarkable thing noted, however, was the fact that the resistance down to a position shortly below 4.2 deg. K. suddenly dropped from a measurable amount to a value practically nil. The temperature at which this happens is called the *spring point temperature*. A measurement of the resistance (so far as this still exists) below 4.2 deg. K. was no longer possible; it was

*From an address published in the *Chem. Weekblad*, Amsterdam, 1919, p. 640. Translated for the *Scientific American Monthly* from the German version in *Die Naturwissenschaften* (Berlin), for Jan. 28, 1921.

only possible to establish the fact that, for example, at 2.45 deg. K. $Wt/Wo < 2 \times 10^{-10}$. This condition of apparently infinite conductivity has been called by Kamerlingh Onnes, *the state of super-conductivity.*

All sorts of questions at once presented themselves as a result of this discovery: Is the resistance really nil in the state of super-conductivity or is it merely exceedingly small? Is it still correct to speak of a resistance and in such case does Ohm's law hold good?

It has not as yet been possible to answer all these questions in a satisfactory manner, but during the course of the experiment a great many remarkable phenomena were observed, which go far toward explaining the essential nature of the state of super-conductivity. In an experiment made to see whether heat was developed by an increase of the strength of the current in a super-conductive mercury wire, it was found that for any given mercury wire it is possible to speak of a boundary value of the current for any given temperature, below which limit no development of heat is to be observed. In some wires it is possible to increase the current up to 1200 amperes per sq. mm. without any difference of tension between the ends of the wire being observable and without the wire's return to a state of normal conductivity. Above this boundary value heat is suddenly developed and the wire then loses its property of being a super-conductor. Whether we have to deal here with the ordinary Joule heat throughout the whole wire caused by the circumstance that even in the state of super-conductivity there is still a residual resistance left or with heat which is developed at only at the imperfect parts of the wire, and which passes from there throughout the whole of the infinitely conductive wire, could not be established with certainty; it was quite certain, however, that the heat did not proceed from the conducting wires or inlet wires. Kamerlingh Onnes was of the opinion that the bad parts of the wire were the probable cause of the development of heat. The only objection to this view is the regularity with which the phenomenon occurs. But whatever its origin this residual resistance which still remains even in the condition of super-conducitvity is termed by Kamerlingh Onnes the *Micro-residual-resistance.* It was further observed that the boundary value fell with the temperature, and that the spring point (or saltation point) varies with the strength of the current, *i.e.*, that the greater the current the lower it is, a fact which is probably to be explained by the usual development of heat. Finally, it was proved that Ohm's law holds good above the spring point.

It is not possible here, of course, to enter into detail with respect to the very difficult and extensive measurements made. If we seek the origin of the micro-residual-resistance in the presence of impurities, then we must come to the conclusion, that impurities are responsible, as in the case of the gold and must further conclude that the "pure" mercury contains only one-millionth part the amount of impurities present in the "pure" gold. But it is difficult to accept this view. When in this connection an attempt was made to compare mercury with gold and for this purpose to carry out measurements with mercury which had been strongly adulterated purposely with gold or with cadmium the surprising observation was made that even this very impure mercury was super-conductive in nature.

After the mercury, *lead and tin* were examined. Tin was fused in a vacuum and then poured into a capillary glass tube. At the temperatures of helium it was super-conductive and its spring point lies at 3.78 deg. K.—lower, therefore, than the spring point of mercury. But the spring point of lead appears to be much higher. At hydrogen temperatures lead is still normally conductive and does not become super-conductive until the helium temperatures are reached. Its spring point was found to lie too high to be ascertained in liquid helium (presumably at about 6 deg. K.). It is noteworthy that amalgamated tin, whose spring point lies at 4.29 deg. K. becomes super-conductive at a higher temperature than do its constituents, tin and mercury.

Besides mercury, lead, and tin, several other metals have been studied, especially in order to find out whether it is possible to discover metals which still possess a sufficient temperature co-efficient in liquid helium, in order to render it possible to make use of them as resistance thermometers at the lowest temperatures. This investigation which was, however, merely directive in character showed that *iron*, *cadmium*, and *copper* possessed a resistance in liquid helium which remained uniform; this resistance is, therefore, apparently to be regarded as a residual resistance, as in the case of gold and platinum, and that on the other hand the constantan and manganin alloys possess a sufficient temperature coefficient and may thus be expected to prove suitable for the making of resistance thermometers.

From all of these investigations we are justified in concluding with great probability that there are still other metals to be found which exhibit the state of super-conductivity, but whose investigation will undoubtedly be attended with great difficulties because of the fact that it is exceedingly hard to obtain these metals in a perfectly pure state.

Another possibility which has occurred to Kamerlingh Onnes but which has not yet received a practical test, is of interest. This concerns the *production of very strong electro-magnetic fields.* It is theoretically possible to obtain a field of unlimited strength, provided only that we can introduce a sufficient number of ampere windings without a core about the space in which the field is to be created. In actual practice we can obtain a strength of field of 100,000 Gauss by means of wire coils which have been proved with liquid air, but it is calculated that on account of the quantities of liquid air which would be required to absorb the Joule heat developed, the cost of the air would be about that of a battleship. But the matter would be very different, if we could employ a wire coil composed of a super-conductive metal. As we have already said, it is possible to send a current of 1200 amp. per sq. mm. through a wire coil of mercury, or a current of 560 amp. per sq. mm. through a coil of super-conductive lead without causing the wire to lose its super-conductive character and without any Joule heat being developed, provided only that we are careful to allow no radiated or conducted heat to reach the wire, so that the strength of the current remains below the boundary value.

It is a peculiar fact, too, that there is no trouble in winding such a coil upon metal provided that the metal itself is not super-conductive. Indeed, an ordinary metal actually behaves like an *insulator* with respect to a super-conductive metal. There is no doubt at all that with a super-conductive coil of about 30 cm. diameter, and with the aid of the Leyden helium apparatus and its appendages, a magnetic field of 100,000 Gauss could be attained at a very low cost.

Because of the well-known phenomenon that the resistance of many metals is augmented as soon as they are brought in to a magnetic field Kamerlingh Onnes made the attempt to see whether the magnetic field also exerted an influence upon the super-conductivity of metal. The test was made with tin wire and lead wire; in the case of both metals *a resistance suddenly appeared as soon as the field had reached a certain degree of strength, and the wire thereupon lost its property of being super-conductive;* the strength of field required to produce this effect, however, is not the same for different temperatures. Thus we see that the introduction of a magnetic field has the same effect as the heating of the wire, and it is possible, therefore, to speak of a boundary value in the case of the magnetic field likewise.

A remarkable experiment.—This brings us to the point where it is proper to describe an especially notable experiment intended to show the duration of the current in a super-conductor—an experiment which cannot, indeed, be said to have revealed any actually new principle, but which, nevertheless, had results so surprising that but a short while ago their mere possibility would have been beyond the dreams of men.

A small closed coil of lead wire was used, consisting of 1,000 turns of 1/70 sq. mm. section and a resistance of 734 Ohm at

ordinary room temperature. Its relaxation time, *i.e.*, the time required for the current produced in such a coil by induction to disappear is calculated to be 1/70,000 sec. The micro-residual resistance was estimated to be at 1.8 deg. K. only $\frac{1}{2} \times 10^{10}$ part as great as at the temperature of the room and the relaxation time must correspondingly amount to, at least, a period of one day at 1.8 deg. K. The experiment was carried out in the following manner: The coil was put in the cryostat and the latter was then placed between the poles of a very large electromagnet, the surface of the windings being perpendicular to the lines of force, so that the coils thus embraced a bundle of lines of force. After a magnetic field having a strength of 400 Gauss had been produced and the coil had attained a state of super-conductivity, the field was reduced within a space of about 10 seconds to a strength of 200 Gauss, and the magnet was then removed after a lapse of about 5 seconds. The number of lines of force surrounded by the coil were reduced within a short space of time, to approximately zero, by which means an induction impulse was produced in the wire and a current excited. The electromagnetic effect of this current was determined by means of a magnetic needle placed at a short distance from the cryostat.

The earth magnetic field was compensated by means of a skilfully placed steel magnet. *The result proved that the induced current really remained in a state of circulation;* naturally, the strength of the current could not be measured in this manner, it was possible to prove, however, that it amounted to about 0.6 amp. still falling, therefore, below the boundary value of 0.8 amp. which had been provided for in the preliminary preparation for the test. Naturally, too, it was not possible to reach a boundary value for the magnetic field, since in this case the wire would have become normally conductive and the current would have disappeared in a short time. It goes without saying that a phenomenon so surprising as this was carefully verified by means of control tests and by a change in the conditions of the experiment. The measurement of the current was also corrected by the magnetic needle, so that it was possible to obtain a degree of accuracy of approximately 2 per cent. In this manner it was finally determined that the decrease in the strength of the current amounted to less than 1 per cent per hour, from which it followed that the time of relaxation must amount to more than 4 days.

If we assume that the micro-residual resistance obeys Ohm's law (which is, however, as we remarked above, by no means certain), we find that in the case of lead this resistance amounts to only a fraction of the resistance at the ordinary temperature, *i.e.*, from $1/0.3$ times 10^{-10} to $1/0.2 \times 10^{-10}$.

But in order to remove every doubt as to whether the observed electromagnetic field might not proceed from the brass mounting of the wire, coil, as to whose magnetic properties at the temperature of helium, no previous knowledge was possessed, Kamerlingh Onnes performed the following ingenious test: Both ends of the wire in the lead coil were soldered to each other in such a manner that they could be torn apart inside of the cryostat at a given point by means of a wire hook operating from outside. On both sides of this breaking point a wire was soldered which led to a ballistic galvanometer. After a continuous current had been induced in the coil the wire was torn asunder. This forced the current to follow the path leading through the galvanometer so as to occasion therein a ballistic outward thrust. As a matter of fact at almost the same moment that this outward thrust was produced, the current had ceased because of the circumstance that an ordinary resistance was now introduced in the circuit. From the outward thrust, just mentioned, it was calculated that a current of about 0.3 amp. had passed through the lead wire.

CONCLUSION

In conclusion let us describe another experiment which was carried out at the suggestion of Professor Ehrenfest; this suggestion was to the effect that a thick ring of lead might be substituted for the numerous windings of the wire coil; it was believed that the induced continuous current must, under such conditions, be capable of becoming very strong, and this prediction proved to be correct. A current of 320 amp. with a density of 30 amp. per sq. mm. (the density in the coil equalled 49 amp.) was detected; it remained constant for a half hour at less than 1 per cent.

Kamerlingh calls these continuous currents in super-conductive metal *imitations of ampere currents.* Ampere was led by the discoveries made by himself and by Oerstedt with respect to the connection between magnetism and electricity to formulate the hypothesis that the field in the vicinity of a magnetic body is produced by a number of exceedingly small circular currents which flow undamped in or around the molecules and that magnetization consists merely of the bringing of these molecular currents into a parallel direction. This hypothesis rendered it possible to ascribe the property possessed by para-magnetic bodies to the effect produced by electric currents. The theory of electrons is, likewise, based essentially upon this concept, in the special sense, of course, that in this case the electric currents are conceived of as consisting of electrons revolving within the atom.

Even in the time of Ampere, however, some doubt was cast upon this hypothesis of *undiminished currents possessing no resistance,* because of the fact that no *example* of such a thing was known. It is all the more remarkable to think that we are now capable of imitating the hypothetical molecular currents of Ampere's concept by the experiments just described with ordinary metal wires. In this connection we may also mention briefly the sensational experiments made in 1915 by Einstein and W. J. de Haas: By means of an extremely ingenious apparatus these experimenters succeeded in proving experimentally that the molecular currents or revolving electrons really exist in a permanent measure; thus the ancient hypothesis formulated by Ampere again holds a place of highest honor.

TECHNICAL EDUCATION IN THE SOUTH

THE unique methods employed by those interested in the future of the Georgia School of Technology to interest the state in the proper support of that institution deserves some note.

Last autumn a distinguished group of Georgians headed by the Governor and the president of the Georgia School of Technology made a tour at their own expense to various industrial and educational centers of the North to see first what was being done there in providing facilities for technical education and, secondly, in what way the raw materials of Georgia entered into the manufactured products of those communities. They were deeply interested in the use made of Georgia clay sold for a few dollars a ton in Georgia in the production of our highest grade pottery and like utilization of many Georgian minerals and other raw materials. They were encouraged to find graduates of Georgia Tech in many high positions and went home determined to provide better facilities for the education of more Georgians and boys of the South generally, and better commercial opportunities for the employment of these boys once graduated.

In April these same men toured their state for a week, visiting more than thirty towns and cities, to recite to the stay-at-homes what they had seen on their northern trip and to impress upon them the necessity of providing more adequate support for the school at Atlanta. Notwithstanding the present industrial conditions, particularly in a state where cotton plays an important part, the prospects are encouraging and those interested in the direct support of a state institution by the citizens as contrasted with appropriations from legislatures are watching developments with unusual interest and hoping that the full program laid down will be realized at an early date.

Scientific Methods of the Paris Police

How Ingenious Modern Methods Are Made to Serve the Ends of Justice

By Jacques Boyer

Illustrated with Photographs by the Author

WHILE it would seem that the number of murderers, thieves, and forgers in our modern world is constantly on the increase and while they appear to be daily becoming more intelligent as well as the possessors of more dangerous weapons and more diabolic tactics, on the other hand, our corps of police and our judicial experts are fully keeping pace with them. Crafty and bold as our "gallows birds" may be and well informed as they are with respect to the scientific methods employed by the police in the detection of crime, our agents of the law are skilled in tracking down and arresting these evil doers—often at the risk of their lives. They succeed in identifying criminals as well as in detecting crime, by means of preliminary operations begun upon the very spot where the latter were committed. They do this by means of skilled specialists and by a careful study of the minutest clues uncovered by minute examinations of the scene of the crime.

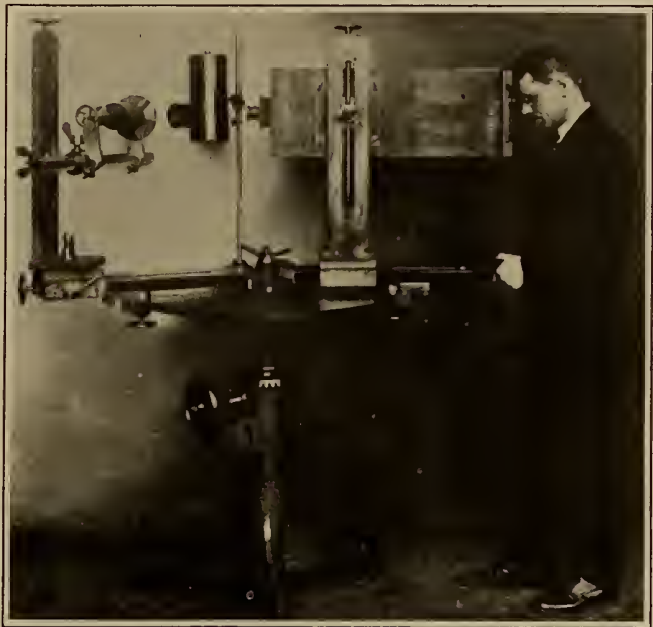


FIG. 1. CAMERA MOUNT FOR PHOTOGRAPHING FINGER PRINTS

The Bureau of Judicial identity which was created in 1883 by Alphonse Bertillon confined itself for a long time to the identification of habitual criminals by means of photographs and anthropometric measurements. Then upon the demand of the Bar "the official photographer of Messrs. Les Attaches" changed his profession into that of a photographic reporter of a special sort. Bertillon and his disciples extended their endeavors to the photography of localities where crimes had been committed and to taking impressions left by criminals upon objects in or near the scene of the crime.

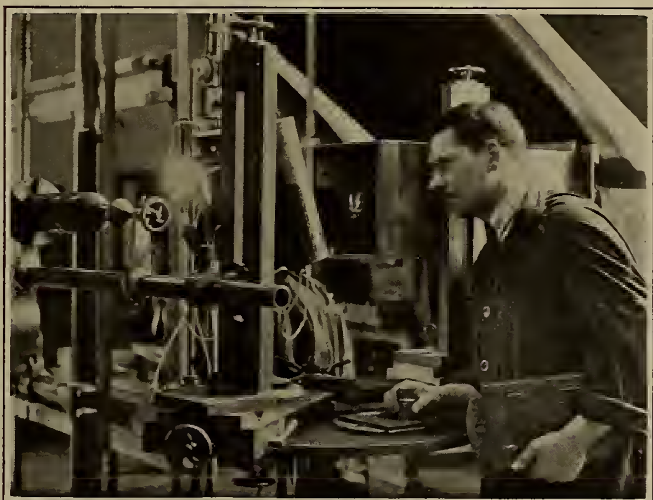


FIG. 2. PHOTOGRAPHING FINGER PRINTS ON A BOTTLE

(Note method of illuminating the object)

Little by little the horizon of the science of "Bertillonage" has extended itself until the modest studio where human measurements were made, has been transformed into a *scientific laboratory of police*, and this laboratory has gained tremendously in importance since it has been presided over by M. Bayle, who is not only a scientific criminologist but a chemist having highly original ideas. This savant was called to be the chief of the bureau in 1915, and he has developed expert judicial methods in the application of physics and chemistry to the detection of crime.

This peerless analyst and his remarkable collaborators possess in most cases only the most infinitesimal *traces* or *clues* upon which to base reports enabling the judges to come to correct decisions—they may have a few drops of a suspicious liquid, an imperceptible spot, minute scraps of clothing, a bit of hair, or a fragment of organic tissues, suffices to set them upon the path at whose other end the criminal awaits them. Even if a criminal has made use of gloves, if he has touched some object in the room where his crime was committed, the impressions which he leaves make it comparatively easy to identify him. If a "crook" has merely changed the date of a government bond by means of chemical reagents, his fraud can be detected by the difference of electric conductibility between an intact portion of the document and that portion where the erasure was made.

By making a microphotographic study of a bit of dust, taken from the edge of a hatchet, an expert can state positively whether the accused owner has wiped the edge of his tool with a bit of rag or with a scrap of newspaper, whether he has killed a human being with it or merely chopped a piece of salt meat in two.

Again, a photograph made by ultra violet rays will show whether the wax seals on a parcel sent by post has been meddled with while a tiny spot of paint straight from a shoelace proved indisputably that the transported criminal Almereyda had hanged himself in a cell.

But before we climb to the top floors of the Palais de Justice where the experts of the scientific police laboratory perform their daily labors let us accompany the staff of the technical section upon one of their expeditions: A crime has just been announced at the police station. A telephone call at once sends to the field a mobile brigade of the technical section (this consists usually of three photographers, a draughtsman, and a finger print expert). As soon as they have arrived at the scene of the crime they proceed to collect all the clues left behind him by the criminal, going through a series of definite processes in a methodical manner according to a *formula* dictated by the Bureau of Judicial Indentification.

The principal items in this formula are as follows: One of the investigators examines the locks of the doors and windows before the party enters while his colleagues photograph the ensemble of the room where the crime was committed and the body of the corpse. Meanwhile, the draftsman draws the plan of the room or of the apartment. When examining the corpse of the victim the staff is directed to describe any disorder of the clothing, any peculiar spot or marks upon the linen and to take a sample of the victim's hair, noting the exact spot from which it is taken; the apparent cause of the death must also be set down with any peculiarities in connection with it, etc. In a strangling case, for example, the observers must endeavor to discover whether the deed was accomplished by a hand or by a cord, and in the second case the latter is brought along together with all connective data. Nothing is left to chance.

We may note especially the peculiar care taken with regard to the directions laid down with respect to blood spots; these include tests made upon the spot with peroxide, location and enumeration and statement of the forms taken, whether in the form of drops, spurts, streaks, pools, smears or wiped up places. Especial care is taken likewise with respect to the observation of foreign substances such as bits of hair, bone, brain matter, etc.

The most infallible method of identification employed today is by the examination of finger-prints. In consequence of this the inspectors must examine with the greatst care furniture, panes of glass, drinking glasses and bottles, or pieces of paper which may have been touched by the criminal. But when such objects are removed the inspectors must be careful to grasp them in a manner impossible for the criminal to have grasped them. In the case of a bottle, for example, it is lifted by placing the forefingers in its neck and the other fingers on the bottom, great care being taken not to touch its side. When broken glass is to be removed it is picked up by the sharp edges, while a drinking glass is lifted by catching the bottom and the edge between the four fingers and the thumb *without touching the sides.*

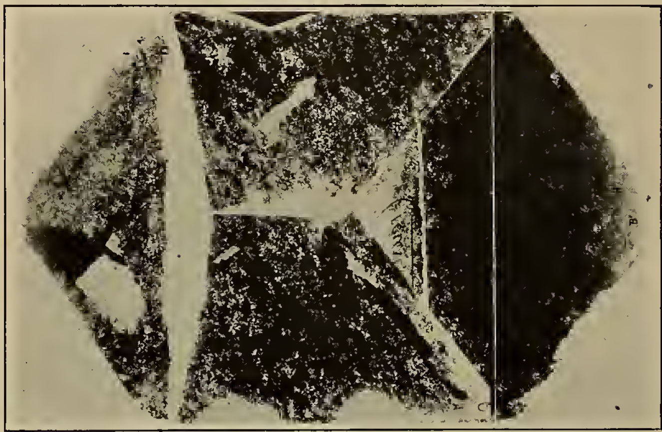


FIG. 3. PRINT BY TRANSMITTED LIGHT OF AN ENVELOPE SHOWING THAT IT HAD BEEN OPENED BEFORE THE SEALS HAD BEEN AFFIXED

In order to transport objects marked with finger-prints to the laboratory, a specially constructed chest is employed in which broken panes of glass, bottles and glasses may be held between adjustable bolts and studs so as to prevent all friction of surfaces covered with authentic "criminal signatures." Finger prints on walls. looking glasses, trunks, and large pieces of furniture are copied on the spot in the following manner: After the print has been colored either by blowing lead carbonate upon it, if it is on a dark background or by lamp black or powdered graphite if it is on a light background, the excess of the white or black powder is removed with a very delicate brush and a photograph of the impression is then made.

Let us now leave the technical section and see how the scientific laboratory of the Bureau of Police in Paris makes use of the materials collected by the members of the mobile brigade for its inspection.

Since finger prints are not very visible Mr. Bayle has had a special apparatus constructed for photographing them as shown in Fig. 1. The camera and the object to be photographed are mounted upon arms which may be swiveled about a table. The illumination consists of two nitrogen lamps (Philips) of 2,000 candlepower each (Fig. 2). By means of this system of swiveling arms the position of the finger prints with respect to the source of light can be changed at will, so as to stand

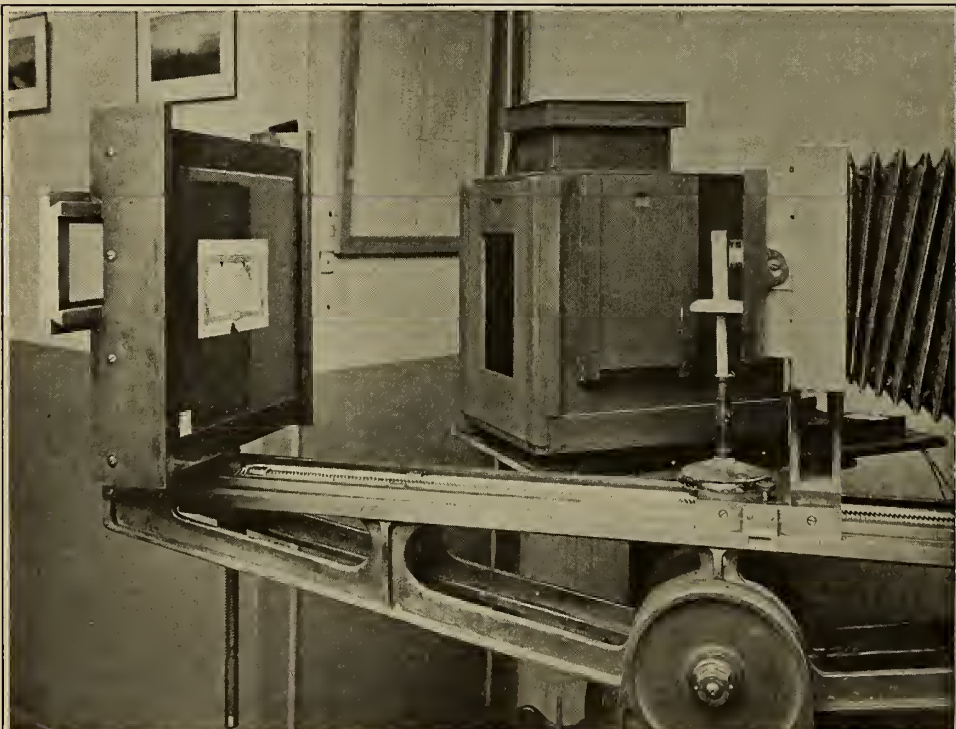


FIG. 4. APPARATUS FOR TAKING PICTURES BY ULTRA-VIOLET LIGHT. ONE OF THE TWO CASES CONTAINING MERCURY-VAPOR LAMPS IS SHOWN IN THE BACKGROUND

FIG. 5. THE MERCURY-VAPOR LAMP FOR PRODUCING ULTRA-VIOLET RAYS

out as strongly as possible upon the ground glass screen of the camera. The images thus obtained are irrefutable witnesses; thus the thumb prints of the right thumb of a suspected individual magnified to 5 diameters are placed side by side with similarly enlarged thumb prints from the scene of the crime. The value of this method is admirably shown by the statistics with regard to the identification and formal inculpation of 123 criminals last year.

Appeals addressed to the special section, 1,203.

Number of finger prints obtained upon the scene of the crime, 2,282.

Comparisons made, 122,205.

Total number of negatives developed, 4,582.

Total number of proofs made, 6,788.

Criminals detected by means of finger prints, 123.

The technical staff next proceeds to make as rapid an examination as possible of the clues obtained, and the results of this investigation are reported in a daily meeting under the presidency of the director of the judicial police and in the presence of the commissioners of the Quarter and the principal inspectors of public safety and of the various districts — all these receive reports of the above meetings.

But the activities of the photographic studio of the laboratory by no means cease here. As arranged by Bertillon it is in possession of a certain number of instruments of precision which serve for the reproduction of the most various documents and objects, as well as for certain researches in the domain of optical physics. (This studio must not be confounded with the Bureau of Anthropometric Measurements in which ordinary photographs, both front view and side view of criminals are taken as a matter of record.) It is in this special studio which is practically a sort of annex to the scientific laboratory of the police bureau that expert, technical, judicial investigations are carried on. Besides making microspectrographic, chemical, or biochemical analyses based upon known reaction in the examination of blood spots, M. Bayle has recently put in operation a combination of general methods fitted for the identification of the spots. In order to illustrate this highly original technique devised by him, let us select four typical examples of criminal acts which he has succeeded in solving.

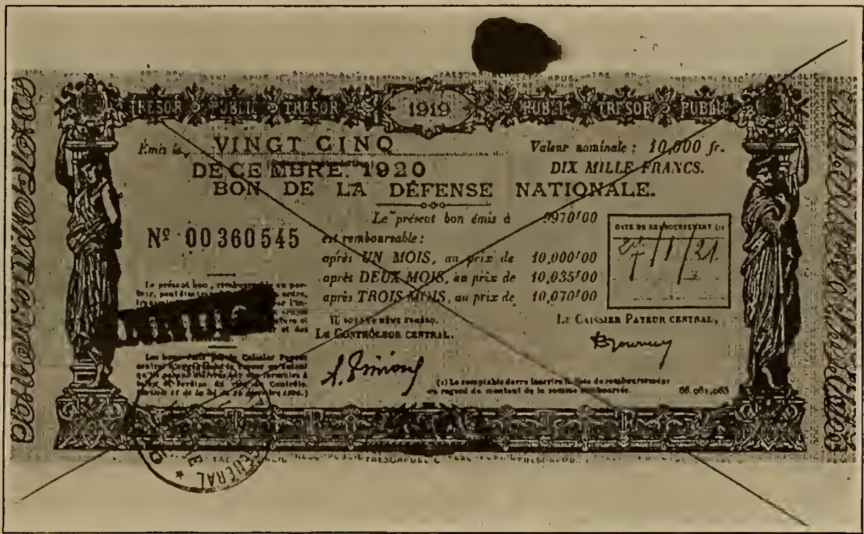


FIG. 6. PHOTOGRAPH IN ORDINARY LIGHT OF A FRENCH BOND WHICH WAS SUSPECTED OF HAVING BEEN TAMPERED WITH

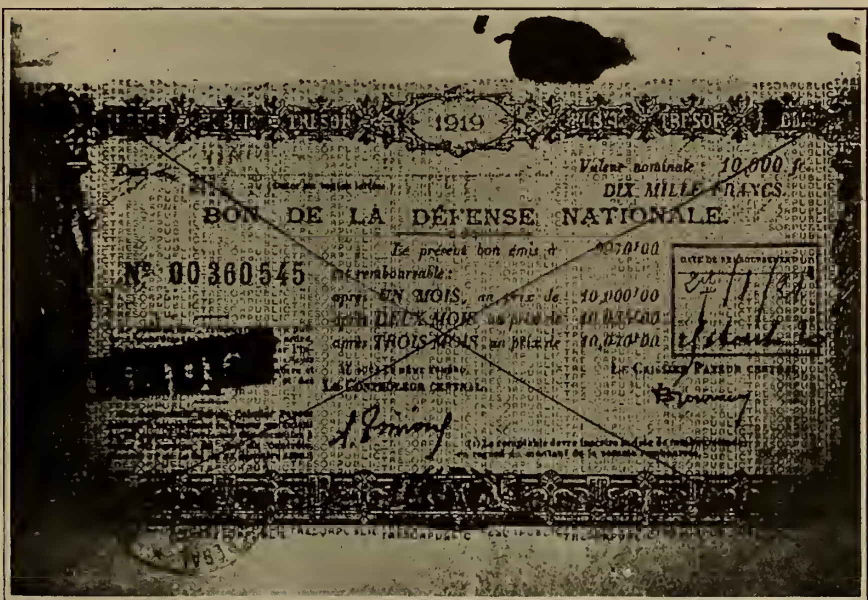


FIG. 7. SAME BOND PHOTOGRAPHED IN ULTRA-VIOLET LIGHT DISCLOSING THE DATE 27 *AOUT* 20 WHICH HAD BEEN ERASED

An envelope sealed with five wax seals was sent to the laboratory. This envelope was supposed to contain 25,000 francs in bank notes, but when opened by the recipient it was found to hold nothing but wrapping paper. In this case the rôle of the expert was confined to circumscribing as much as possible the necessary researches of the *Juge d'Instructions* by searching for clues which the thief might have left upon the exhibit. Since the wax seals appeared to be absolutely intact, M. Bayle proceeded to dissolve them in a benzo-alcoholic mixture. He then saw that the paper bore no trace of being torn underneath the seals — hence the thief had not removed them. Continuing his examination he immersed the envelope in water in such a manner as to cause the different parts of it to come undone from each other, after which he spread them out and photographed them by transmitted light. In this manner the key to the mystery was at once found. A part of the band torn off by the instrument which had opened the envelope remained glued to the other side of the fold (Fig. 3). Furthermore, there was a small particle of wax at one point of this tear, consequently, it was evident that when it was sealed, the break in the paper had already existed. Since it was also found out at what time the seals had been placed upon the letter it was an easy matter to deduce the fact that the theft had been made in the house from which the letter was sent and in the room occupied by a certain employe.

Let us turn to another instance in which the problem was solved, this time in a negative manner, by means of a microphotograph. A hatchet with a blade which had been stained in some manner and then wiped off, was sent to the laboratory with the request that an endeavor be made to find out whether it had been dried by means of a rag or by means of a piece of newspaper. A few minute fibers were found clinging to the scratches upon the hatchet and these were first colored with Selleger's (Zelleger's) reagent (iodated nitrate of calcium), and then examined under an enlargement of about 3,000 diam. This reagent stains cotton fibres a pink color and fibres of

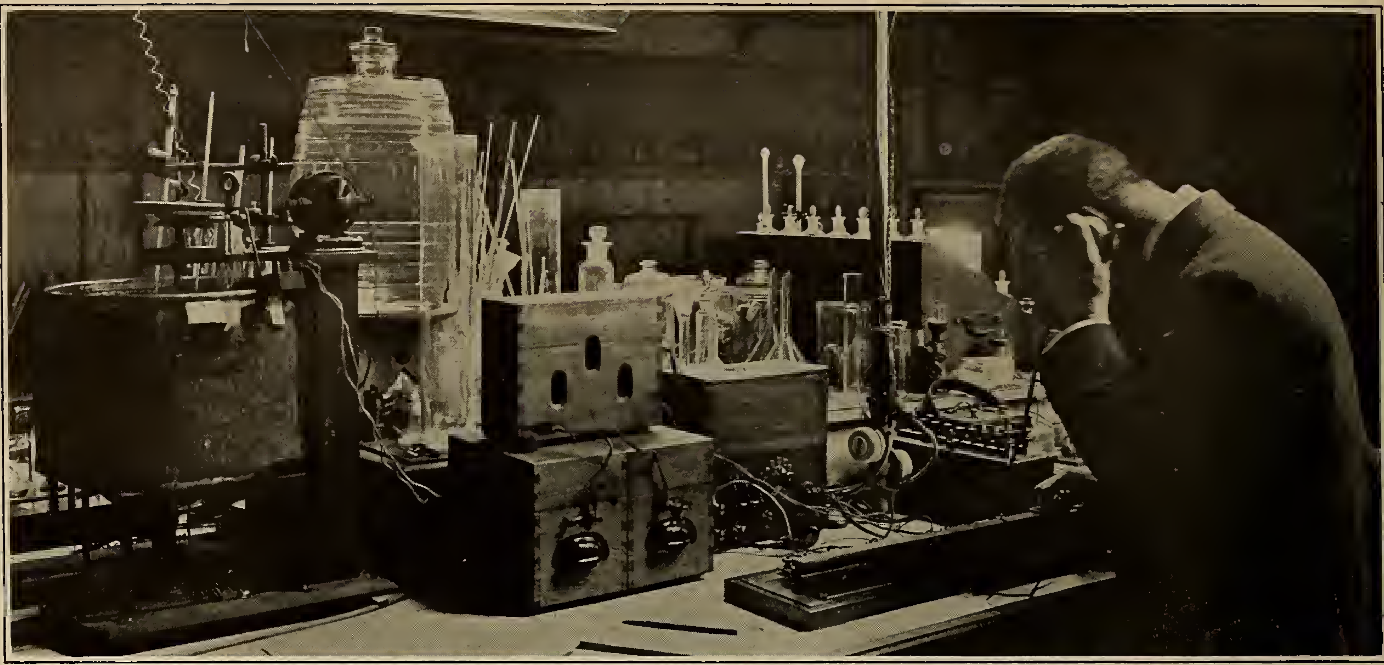


FIG. 8. SENSITIVE ELECTRICAL APPARATUS FOR DETERMINING MINUTE QUANTITIES OF CHEMICAL SUBSTANCES

newspaper (which is manufactured from wood pulp) yellow; the form of the cotton fibers also differs greatly from that of newspaper fibers. In this case only cotton fibers were found so that the examiners concluded that the hatchet had been wiped with a piece of cloth and not with a newspaper belonging to the suspected man. Finally, and this was of far more importance in establishing the innocence of the suspected criminal, the analysis revealed no trace of blood, but only a bit of moist dirt containing 80 per cent of sea salt. This showed that the suspected instrument had not been used to kill anybody but had merely been employed for cutting a brine cured ham!

DETECTING FORGERY BY ULTRA-VIOLET RAYS

Ultra-violet rays also furnish a means of great precision in the detection of certain cases of forgery. In the Police Laboratory the Henri George Mercury Vapor Lamp (Fig. 5) is used for this purpose because of the very powerful ultra-violet rays which it emits. It is enclosed in a specially constructed lantern and provided with a screen made of a special glass which is opaque to visible light but transparent to ultra-violet rays. It is a well-known fact to students of these rays that certain substances, such as sulphate of quinine, nitrate of uranium and the platino-cyanide of barium when exposed to them become fluorescent, while other substances, such as a spot of blood, for example, remain dark.

M. Bayle has had the clever idea of utilizing this fact as a means of detection in certain cases of crime. For example, one of these substances may be suspected of forming a portion of some article connected with a criminal case, obviously if it does form such a part its presence can be detected by the ultra-violet rays without the necessity of injuring or destroying the article in question. Although the technique of this new method of examination is not yet fully formulated, some very brilliant results obtained in this manner may be mentioned. A very striking instance was that of the theft of a million francs' worth of government bonds of the National Defence issue. These bonds had already been called in and paid when they were stolen from the French Treasury. The forger carefully erased the dates which had been written in by hand and inserted new dates, whereupon they were presented for payment a second time.

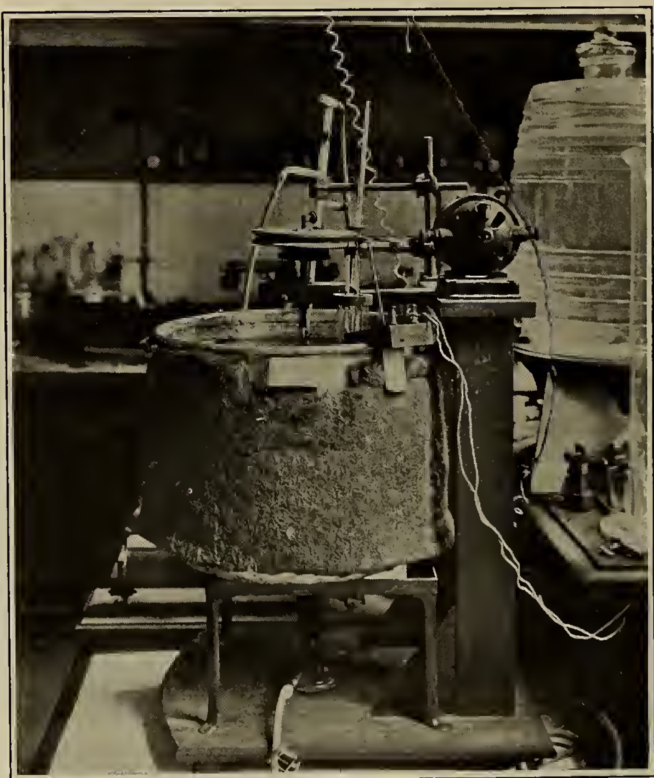


FIG. 9. CLOSE-UP VIEW OF THE THERMOSTAT SHOWN IN FIG. 8

M. Bayle photographed one of these bonds in ordinary light (Fig. 7) and then took another negative by means of ultra-violet light (Fig. 6). As our photographs show the effaced date is quite invisible in the first photograph but in the second one it plainly appears as follows: *25 Aout 20.* It should be observed also that the stamp showing payment upon the date *Decembre 1920*, for which a greasy and non-fluorescent ink was employed has likewise disappeared in the picture taken by the ultra-violet radiation. In order to take negatives of this sort the Bertillon photographic apparatus (Fig. 4) is made use of, because of the fact that by a system of gearing the orientation of both the photographic plate and the document may readily be changed. The latter is illuminated by means of two George mercury lamps placed symmetrically on one side and the other of the camera. A screen interposed between the lens and the article to be

photographed absorbs all of the visible rays of the spectrum.

Furthermore, in order to determine the precise circumstances under which the theft took place the judge requested the experts of the laboratory to make an effort to determine whether there was any complicity between the person who was found in possession of the package of bonds and one of his presumed accomplices, in whose residence there had been seized a package of blotting paper covered with spots. The point to be determined was whether the substance which had made these spots was identical with the chemical solution which had been used to wash off the date upon the bond. In other words, whether at a given moment these blotters had been in contact with the bonds or lying near them. As we see this problem presents difficulties quite insuperable by the ordinary physical and chemical methods of inquiry, since it was necessary not only positively to affirm their identity, but also to state the proper amounts capable of being applied, in case one and the same liquid taken from one and the same bottle had been utilized.

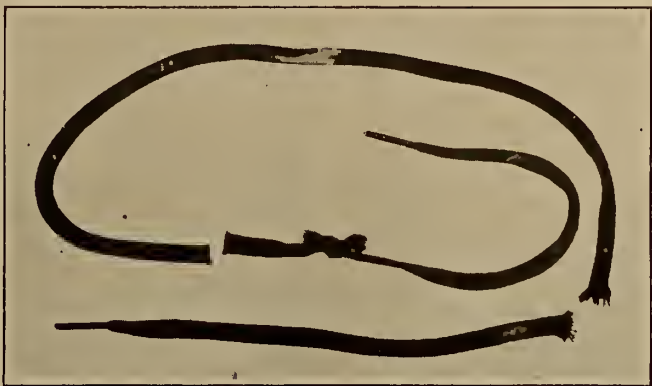


FIG. 10. SHOE STRING WITH WHICH A NOTORIOUS CRIMINAL HANGED HIMSELF

ELECTRO-CHEMISTRY AS A DETECTIVE AGENT

M. Bayle solved this problem in the following ingenious fashion by calling to his aid an electrochemical test.

The method used in this case was based upon the following ideas which are very simple in principle. When a circuit is formed comprising a battery, an alarm bell and two sheets of copper immersed in a vessel full of water the bell will sound only if a little sea salt be thrown into the liquid. Hence the quantity of electricity which passes between the two sheets of copper will indicate the weight of the salt or other electrizable substance which has been introduced into the cell, and the current will increase in strength with very great rapidity in proportion to the amounts of salt added. M. Bayle, therefore, conceived the clever idea of constructing an experimental contrivance (Fig. 8) capable of measuring the extremely minute degrees of electrical intensity thus produced and of determining in this manner the infinitesimal amounts of electrolytic substances contained in the liquid of the battery cell. For this purpose a varying resistance (Wheatsone bridge) of known quantities as small as one desires are compared to the resistance to be estimated; this is done by moving a slide which runs along a carefully calibrated platinum wire, 1 meter in length, which is stretched lengthwise along a scale graduated in millimeters.

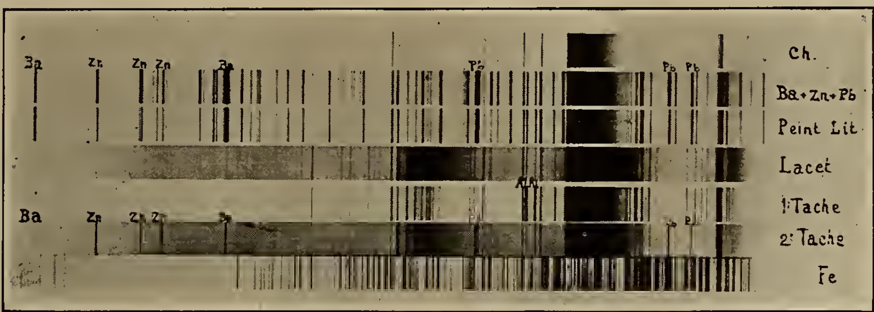


FIG. 11. SPECTRA SHOWING THAT A SPOT ON THE SHOE LACE WAS MADE BY PAINT FROM THE BED OCCUPIED BY THE CRIMINAL

The alternating current required is produced with all the rapidity necessary for the observations by means of a small induction coil operated by a storage battery. When the telephone bell introduced into an intermediate circuit is silent a state of equilibrium is indicated; this shows that the resistance sought is at this instant exactly equal to the opposed resistance. An audion composed of three lamps similar to those employed in wireless telegraphy, increases the sensitiveness of the method by amplifying beyond the state of equilibrium, the current by which the measurements are made. Finally, in the bath of the thermostat shown in Fig. 9 two electrodes are immersed; these consist of two small concentric cylinders made of platinum and protected by a glass case; this permits the experimenter to determine the matter with 20 drops or so of liquid. The small electric motor which appears beside the thermostat sets in motion an electric fan designed to render uniform the temperature of the water which is maintained at a constant point by means of a Bunsen burner.

In order to make a measurement after the current has been thrown into the coil, the operator takes hold of the microphone of the telephone with his left hand. He then hears it ringing and he moves the slide until he can no longer hear any sound. At this instant the resistance due to the added salt is equal to that which was to be determined, and the amount is shown by the figures upon the scale at this point.

This being clearly understood let us now see how ingeniously this method was applied for detecting the forgery in the government bonds described above. The experimenter cut out by means of a punch a circle of paper in a part of the bond where an erasure had been made, and then with the same punch he made several similar holes in intact portions of the same document, One of these "confetti" was dropped into the bath of the thermostat whereupon this minute fragment of paper containing within the substance which composed it, a trifle of soluble matter, gave up the latter to the liquid, thus modifying its electric conductivity and interrupting the equilibrium. Thereupon, the experimenter restored the equilibrium as described above by moving the slide along the platinum wire. As soon as the telephone bell fell silent again the figure upon the ruler indicated the amount of soluble matter originally contained in the circle of paper. By treating in the same manner a piece of paper of the same size but taken from an intact portion of the document, the position at which equilibrium occurred was found to be at a different point. Furthermore, under given conditions of experiment each salt yields a figure which is characteristic to itself and typical of its molecule, so that in this manner it is possible with but little work to compile a comprehensive table of molecular conductibilities.

If the solution used in the experiment consists of a mixture or contains impurities, these will play a part in the average conductivity and it is plain to be seen that under the given conditions, if we obtain identical figures, we are perfectly justified in forming the conclusion that the two liquids being studied are identical. In order to throw light upon the case of the bond forgeries, in question, M. Bayle was obliged to make a series of measurements upon lacerations of paper reduced to the same content of chlorine by means of titration and being sufficiently dilute for the impurities present in the paper to count for practically nothing as compared with the substance experimented upon.

A comparison of the intact areas with the areas where erasure had occurred, brought out very suggestive differences. This is admirably shown by the figures expressing the resistances in ohms of the same voltage of distilled water, in which there had been soaked for an equal length of time equal areas of the erased paper and the original document:

Circule of paper cut from the erased portion (forged)	812
First circle of paper cut from intact area	464
Second circle of paper cut from intact area	451
Third circle of paper cut from intact area	472

This table shows clearly that that part of the paper where the date had been forged exhibited a much stronger resistance —about twice as great—as the intact area of the same bond, by reason of the fact that a portion of its soluble substances has disappeared in the course of the fraudulent washings it had undergone. Sometimes, however, the contrary effect is produced because of the lack of skill on the part of the forger who had failed to wash the paper thoroughly, in which case there remains a trace of the reagent used to destroy the color, so that upon examining the area under suspicion it will be found to exhibit a smaller degree of resistance. However, since it is an ill wind that blows no one any good, according to the proverb, the figures obtained in this case serve to identify the reagent employed by the forger.

The precision of this method is so great that one ten thousandth part of a milligram can be detected by it. Thanks to its use M. Bayle was able to conclude not only that the spots on the blotters contained hypochlorite of lime (Javel water)—which ordinary chemical analysis would have revealed, but it was the *very same liquid* which had been used in falsifying the bonds.

In other analogous affairs he recognized specifically the common origin of various spots found on documents taken from various persons, thus establishing the complicity of the latter.

THE SPECTROGRAPH AS A CRIME DETECTOR

The spectrographic method of analysis has also been perfected in this laboratory. A single example will suffice to show its delicacy and we may conclude our remarks by an account of a famous case in the *Bonnet Rouge*. Upon the shoe laces (Fig. 10) of the notorious Vigo, known as Almereyda, who died very suddenly in the hospital ward of the Prison of Freynes two spots were found, one of which was much bigger than the other. The judge in charge of the case asked M. Bayle to analyze these, as is shown in Fig. 11. The skilled expert compared the spectra of the two spots, of the intact portion of the shoe lace, and the paint on the bed occupied by the criminal. He thus proved conclusively that one of the spots consisted of mud (giving an aluminum-ray), while the other possessed the rays characteristic of the paint on the hospital bed (lead, zinc, barium). It was thus found that the convict had hanged himself in his cell! A mere spot upon a shoe string was sufficient to reveal to a savant the sad end of this unhappy creature.

* * *

Let us finish our visit to the laboratory by the exchange of a few words with its young director. * * * In one of the conversations in which he revealed some of the secrets of his profession he remarked modestly: "All this is only a beginning."

As a matter of fact, we have here reported only a portion of the new processes invented by this eminent expert chemist.

PECULIARITIES OF THE HUMAN NAILS

A GREAT many animals possess claws which both assist them in walking and act as weapons of defense or offense, sometimes of a very terrible nature; likewise, they often serve in grasping their prey, but it is only human beings and certain families of apes which have *flat* nails upon their fingers and toes. It is an interesting circumstance, however, that the nails of apes and of men differ strikingly from each other in the fact that the quick of the nail is very strong in the former and very weak in the latter. Only the great toe of all apes (with the exception of the orang-outang bears nails which resemble those of man in this respect, being equally poorly provided. In fact, the nails of the "semi-apes" resemble those of man more strongly than do those of the great apes or anthropoids. According to a recent German writer, H. Friedental, whom we find quoted in the *Naturwissenschaftliche Umschau d. Chem.-Zt.* (Berlin) for Jan., 1921, remarks concerning this that practically the only difference between the nails of these semi-apes and those of man consists in the fact that the former possess a claw upon the second toe of each foot. The nails of these half apes are as slightly curved and as scantily provided with the "quick" as those of man.

Upon the hand of a human being the nail of the second finger is usually the flattest in shape, the curvature increasing in the following order: first, third, fifth and fourth. This curvature is most marked during the first two years of a child's life, being most prominent of all before birth and shortly thereafter.

With respect to the development of the breadth without respect to the curvature, the series of finger nails generally runs as follows: one, three, two, four, five. The longitudinal curvature, however, is very slight in flat nails and often not present at all in the thumb nail. Extra-European races have more strongly curved nails than any of the white races. Even in colored races of men the layer of horn is so transparent that the bed of the nail, which is poor in pigment, shines through with a red color. This is not the case, however, in apes.

The chief function of the nails is to scratch and they make excellent weapons. In digging up edible roots the finger nails of men are of as much service as those of apes. The loss of the nail greatly interferes with the more delicate functions of the fingers, whereas there is no perceptible interference with the use of the toes from such a loss. As respects its origin the flat nail can be apparently traced to a simple digging claw. This is indicated by the fact that in the man-like apes a primitive nail, a sort of primeval claw first develops above the end of the finger and is not shed until after the animal's birth. From the end of this primitive nail nearest the body, the horny plates of the secondary flat nail are developed. Furthermore, the innervation of the nail members proceeds from the lower side which corresponds with the idea that the flat nail has its origin in the base of the primitive claw at the end of the finger.

A NEW CINEMATOGRAPH LAMP

THE ordinary cinematograph lamp for currents between 30 and 70 amperes, or even up to 100 amperes, has the carbons in line, and only slightly tilted from the vertical, so that the crater of the upper carbon shall burn away in front. From 5 to 7 handwheels are fitted to permit common and individual adjustment of the carbons, so that the crater may be kept in focus, from which it is continually tending to depart. Obviously the optical conditions can be much improved by making the upper (positive) carbon horizontal, but it has hitherto been found impossible to stabilize the arc in this type of lamp with a higher current than 30 amperes.

In their new projector lamp, the Körting & Mathiesen Co. claim to have solved the problem of satisfactory burning with horizontal positive carbon using currents as high as 80 amperes. The crater being practically vertical, from 25 to 50 per cent more light is said to be projected on to the screen for equal watt consumption, and the screen is moreover uniformly illuminated top and bottom. Only three hand-wheels are necessary, one for raising and lowering the lamp vertically, one for common movement together of both carbons, and one for advancing or withdrawing the top carbon. The arc is centered by a blow-magnet. Satisfactory operation is claimed on alternating current as well as direct current. Polar curves of the new and old types of lamp are reproduced.—*Electrotechnik und Maschinenbau.* Abstracted by the *Technical Review.*

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

THE EFFECT OF LIGHT ON GERMINATION

In a very exhaustive article in the *Botanical Gazette* for April, 1921, Dr. Wright A. Gardner of the Alabama Polytechnic Institute presents the results of investigations on the effect of light on the germination of light-sensitive seeds. Introducing his article, the author says:

Various explanations have been offered for the germination of light-sensitive seeds, and several conditions have been shown to favor or make possible the germination of such seeds. Rupture of coats, increased water supply, variation of quantity and intensity of light, reciprocal relation of heat and light, reaction of substratum and embryo activation of enzymes, increased oxygen pressure, increased carbon dioxide pressure, and "certain inhibiting agencies" have been suggested as factors affecting the germination of light-sensitive seeds. Although quite possible, it seems hardly probable that no one of these is the fundamental or controlling factor. It would seem rather that one or two of these agencies are fundamental and the others accessory means of setting in motion the processes that finally bring about germination. Enzyme action has been suggested repeatedly as a fundamental cause of germination, but no one has ventured to demonstrate the relation of enzymes to the germination of light-sensitive seeds.

The author's own investigations were intended to discover the fundamental relation of light to the germination of seeds, and to show just what light does to start germination. The experiments concerned such subjects as:

Germination in light and darkness.
Light sensitiveness, after-ripening, and viability.
Mechanical rupture.
Temperature and light.
Effects of alternation of temperature, light, and darkness.
Hot water treatment.
Water absorption.
Injection of seeds with water.
Increased oxygen.
Effects of electrolytes.
Lipoid solvents.
Enzymes.

Results of the investigations are summarized as follows:

1. The seeds of *Rumex crispus*, *Datura Stramonium*, and *Phoradendron flavescens* were found to be light sensitive. The germination of seeds of *Rumex crispus* and *Phoradendron flavescens* was promoted by light; the germination of seeds of *Datura Stramonium* was hindered by light.
2. Abrasion and removal of coats (ovary walls) of *Rumex crispus* seeds promoted their germination in darkness.
3. Treatment of seeds of *Rumex crispus* and *Oenothera biennis* with concentrated sulphuric acid caused an increase in the percentage of germination in darkness.
4. No reciprocal relation between the effects of light and temperature was found.
5. Light was not necessary for the absorption of sufficient water for germination.
6. Injection of water did not yield increased germination in darkness.
7. Almost all kinds of single electrolytes, regardless of the nature of the ions, seemed to promote germination of seeds of *Oenothera biennis*, *Nicotiana Tabacum*, and *Verbascum Thapsus* in darkness.
8. Embryos of seeds incubated in light became more acid than those incubated in darkness.
9. Light seemed to activate lipolytic enzymes which hydrolyzed fats to fatty acids.
10. The germination of seeds of *Rumex crispus* in darkness was promoted (increased) by hot water treatment, abrasion, treatment with concentrated sulphuric acid, increased oxygen pressure, fluctuating temperatures, and soaking in solutions of hydrochloric acid, sodium sulphocyanate, and hydrogen peroxide.
11. The germination of seeds of *Nicotiana Tabacum* in darkness was promoted by soaking in solutions of hydrochloric acid, sodium sulphocyanate, and hydrogen peroxide, as well as by the use of many single electrolytes as substrata.
12. The germination of seeds of *Verabascum Thapsus* in darkness was promoted by the action of light, fluctuation of temperature during incubation, alternating high and low temperatures, soil, and many single electrolytes as substrata.
13. The germination of seeds of *Oenothera biennis* in darkness was promoted during certain seasons by hot water treatment, sulphuric acid, preliminary incubation at low temperature, incubation in alternating high and low temperatures, and single electrolytes as substrata.
14. The germination of seeds of *Daucus Carota* in darkness was promoted by increased oxygen pressure and preliminary incubation at low temperature, while it was hindered by soaking in hydrochloric acid and by the use of single electrolytes as substrata.

THE NUTRITIVE VALUE OF YEAST IN BREAD

In the *American Journal of Physiology* for May, 1921, Messrs. P. B. Hawk, C. A. Smith and Olaf Bergeim of the Laboratory of Physiological Chemistry, Jefferson Medical College, present an interesting article on the nutritive value of yeast in bread.

"In view of the fact that bread is the chief of staple foods," the authors state "it is of importance to know whether the yeast used in its preparation should be looked upon merely as a generator of carbon dioxide or whether yeast improves the nutritive value of the loaf. If, as seems clear, yeast must of itself be considered as a food, it is of importance to know in what way it supplements the other ingredients of bread and in what amounts it should be used to obtain a product of maximum nutritive value. Also we cannot afford to underestimate the possibility of yeasts ultimately replacing in the diet certain other important foodstuffs."

It has been known for a number of years that the ash of yeast is especially rich in the important element phosphorus, containing at the same time very considerable amounts of potassium and lesser amounts of the inorganic elements essential in nutrition. Yeast also contains a considerable amount of carbohydrate, including cellulose and gum-like substances and glycogen. It is high in protein and in a nucleic acid yielding purine and pyrimidine bases, a pentose, and phosphoric acid on hydrolysis.

That yeast contains an antineuritic substance was shown by Schaumann. Hopkins first showed yeast to contain a substance small amounts of which accelerated the growth of rats fed purified foods. These observations have been repeatedly confirmed and extended until it is now generally recognized that yeast is one of the richest and cheapest sources of water-soluble vitamine.

The authors' experimental procedure was as follows:

Young male albino rats, obtained from the rat colony of the Wistar Institute of Anatomy, were used as experimental subjects, and were divided into two groups of eleven rats each. The attempt was made to have the two groups as nearly alike

as possible at the start of the experiment. The average weights for the two groups at the start were 60 and 61 grams respectively.

The rats in one group were fed white bread made to approximate closely standard home-made bread, while the rats in the other group were fed bread made with considerable extra yeast. The high yeast content was obtained by mixing 5 per cent of dried compressed yeast with flour and by using six times as much fresh yeast as was used in making the standard bread.

The results obtained showed that on the average the rats fed extra yeast bread gained 66 grams in 11 weeks or nearly three times as much as the rats fed standard bread (23 grams), average gains per week being 6 grams and 2 grams, respectively. The rats fed extra yeast were also far superior in general physical appearance.

Commenting on these results, the authors say that the bread used as a standard was by no means a poor quality bread but on the contrary was somewhat better than the average as the liquid used in its preparation was one-half milk, which is absent from some products. About ten per cent of the protein of this bread was milk protein, while about one-fifth of the protein of the extra yeast bread was yeast protein, the latter also of course containing milk, to make a total of about 30 per cent of non-wheat protein.

Patent wheat flours and breads made from them without suitable addition are known to be deficient in water-soluble vitamine and in protein. The use of milk to the extent of one-half the liquid required or sufficient to replace 10 per cent of the wheat protein by milk protein did not lead to significant gains in weight, in spite of the higher quality of the proteins of milk. That the milk addition should furnish sufficient water-soluble vitamine would not be expected from the relatively low vitamine content of milk as indicated by the work of Osborne and Mendel, who found even 15 cc. of fresh unpasteurized summer milk inferior to 0.2 gram of dried yeast in this respect.

The conclusion is reached, therefore, that "flour containing 5 per cent of yeast powder makes a palatable bread much more nutritious than ordinary bread. Yeast is thus a nutrient constituent of bread, and any increase in its amount up to quantities far in excess of those ordinarily used will improve the food value of the product."

THE DUST OF THE UPPER AIR

Two distinct shells of air compose the atmosphere. The plane of contact between them is approximately 7 miles above sea level, varying slightly with latitude and with the season. The upper shell has been explored to a height of about 20 miles, but extends many miles beyond. So far as known its movements are tidal rather than convectional. Its composition differs slightly from that of the convectional region also. If water vapor exists, the proportion is too minute to form cloud matter. Argon disappears at a height of 40 miles. Carbon dioxide is absent. Above 70 miles hydrogen, helium in minute proportions, and dust constitute practically all there is to the upper air. The diffusion of matter within the stratosphere follows the ordinary laws which govern such movements. Electrical disturbances of Hertzian-wave character are frequent in the upper air and these undoubtedly aid in the diffusion of its dust content, which apparently is highly ionized.

The lower shell of air is the convectional region. The laws of diffusion apply to its content, but convection is the chief factor in the mixture of its constituents. Aside from its lateral movements, the winds, there are also general vertical movements; air is both going up and coming down. The general movements of the air, rather than the laws of diffusion, govern the movement of its dust content.

Coarser particles picked up from the ground fall very quickly. Small particles, especially those of less than 1 micron, fall so slowly that, in many instances, the rate of fall is not measurable; indeed, highly ionized dust particles apparently do not fall at all. If they are brought to the ground it is because they become nuclei of condensation, and not because of their own gravity. Even then, as soon as freed from their load of water, they escape into the air again. In other words the extremely fine dust particles behave much as does molecular matter. Especially is this the case when they are ionized—and possibly their ionization is constant.

The rate of fall of larger particles has been measured. Investigations carried on under the direction of the Transvaal Bureau of Mines show that particles 1 micron in dimension require about five hours to fall six feet. W. J. Humphreys finds that, at cloud height, particles 1.85 microns in dimension fall at the rate of 1 centimeter per 25 seconds, or a little more than 1 inch per minute.

In the region of convection, dust particles are nuclei of condensation. They are essential in the formation of fog and cloud substances. Rain and snow not only bring them to the ground, but also sweep the air free from floating matter of every sort. A snowstorm will rid the air of about everything except the blue haze. The air is never wholly free from dust, however; the cleanest free air carries from 10,000 to 20,000 dust particles per cubic inch.

The foregoing survey of the floating dust of the air is necessary to an understanding of its effects on certain irregularities in the temperature of the air.

Floating dust is mainly the product of volcanic energy. Most volcanic eruptions are steam explosions—that is, the escape of steam and probably other gases, under a pressure that must be reckoned in tons rather than in pounds per square inch. The gases, hydrogen, helium, and sulphur dioxide, along with a generous proportion of water, are a part of the rock which becomes volcanic ejecta. They are occluded within the magma which becomes lava. When the pressure is released the expansive force of the steam and gases blasts the lava into dust and shoots the dust twenty miles or more into the air.

The character of the dust bears evidence of the manner in which it is formed. Dust belched from Krakatoa was caught on slides at Los Angeles a year or more after the eruption. Petrologically the particles were identical with furnace slag. Physically most of them were bubbles of microscopic dimensions. Meteorologically, *en masse*, they formed a screen which intercepted so much of the sun's heat that for about two years the temperature of the air was materially lowered.

The statistics from many Weather Bureau stations report temperature means materially below normals for 1884-1885.

The effect of a dust screen on temperature was pointed out by Benjamin Franklin.

In presenting humanity with values that have a very practical application, Humphreys has gone a step farther than Franklin. He has shown that for every unit of the sun's heat coming to the earth but intercepted by the dust screen, thirty times as much heat is radiated by the earth into space.

One may safely conclude that the effects of a prolonged dust screen on life are profound.—Abstract from article by Jacques W. Redway in *Biology* for April, 1921.

SELECTIVITY OF PAINT AND WINDOW IN PHOTOMETRIC SPHERE

WRITING in the *Electrical World* of Feb. 12, 1921, F. E. Cady describes experiments for the measurement of the error introduced into a photometric determination of the average candlepower of a tungsten-filament vacuum lamp, operating at normal efficiency, when using a comparison lamp tinted so as to match a kerosene flame in color. The error was found to be between 4.5 and 5 per cent when the selectivity of the paint and window of the sphere was such as to introduce a color difference corresponding to a temperature difference of 400 deg. cent. in the vacuum lamp. It is considered that errors of the same order of magnitude may be introduced in the measurement of a gas-filled lamp by means of a vacuum type comparison lamp.

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

BALLOONS, HELIUM GAS, AND THE AGE OF THE EARTH

By Homer P. Little,

Secretary, Division of Geology and Geography National Research Council, Washington, D. C.

PHYSICIANS are attempting to cure cancer and goiter, among other diseases, by radium treatment; balloons are being filled with a gas which will not catch fire from an incendiary bomb; physicists, who a few years ago grudgingly allowed the geologist one hundred million years since the earth became solid at the surface, will now as willingly grant him a billion. At the root of all this is uranium, which is the parent of radium and, in part, of helium.

As everyone with even small chemical training knows, hydrogen gas mixed with air is explosively combustible. Yet, until recently, the balloon of the aeronaut, the Zeppelin of the German, and the dirigible of commerce, were most commonly inflated with this gas and subject to the accompanying dangers. A single lightning flash or an incendiary bullet and their careers were over. Helium gas, however, is exceedingly inert, *i.e.*, it tends to remain just helium gas, unchanged under the most varying conditions to which it can be subjected. In this it is much like the heavier nitrogen gas which makes up almost 80 per cent of the air we breathe, but which man has only recently been able to take directly from the air and force to combine with other substances to form nitrogenous compounds for fertilizers. In 1914 a British scientist conceived the idea of using helium in place of hydrogen for inflating balloons. Since helium gas has 93 per cent the buoyancy of hydrogen this was a perfectly practicable idea, but it was a case of first find the gas. Indeed, after a careful search of England and Canada, the project had to be abandoned. The Italians made similar attempts and failed. When the United States entered the war, the Bureau of Mines was assigned the problem and the outcome was another triumph for the men of science of this country for "at the time the armistice was signed, November 11, 1918, the first shipment . . . of 147,000 cubic feet of 93 per cent helium . . . was on the dock awaiting transportation to Europe."[1]

The Director of the United States Geological Survey once defined "pure science," as "not-yet-applied science," implying that there is not the radical difference between the two which the layman supposes. The history of helium is one of the continually accumulating body of facts which illustrate this. Helium was first discovered in the atmosphere of the sun during the study of an eclipse. This was in 1868. Almost 30 years later, in 1895, it was discovered in the earth, first in certain minerals and a few months later in the atmosphere. Careful investigation has since shown it to be present in small amounts in many minerals and rocks, in some mine gases, in the gases of many mineral springs, and in some natural gas. Most important of all, from the standpoint of its commercial utilization, was the discovery about 1905 that the natural gas of Kansas contains helium. To be sure the largest per cent found in any Kansas gas was 2.13 per cent, but when it is remembered that these wells yield millions of cubic feet of gas a day, a natural gas containing even 1 per cent of helium becomes a very valuable source of supply. The importance of this discovery is still more evident in the light of a statement made in 1912 by a foreign authority without consideration of the helium bearing natural gas of the United States, that certain mineral springs producing 1,200 cubic feet of gas a year from their waters were the most prolific source of the element then known.

Investigation has shown that "while most of the natural gas produced in the eastern and central parts of the United States contains at least a trace of helium, gas containing more than 0.5 per cent is known to occur only in two areas, one in northern Texas and the other in southern Kansas and northern Oklahoma." At present 0.5 per cent is about the lowest content consistent with reasonable cost of production. With at least this amount, if the gas is recovered in large-scale plants, the cost should not be over \$60 to \$80 per thousand cubic feet, with the prospect of appreciable further reduction through a promising new process already in operation.

Theoretically, the isolation of helium gas is simple. It is much like obtaining by fractional distillation from crude petroleum the successive products gasoline, kerosene, and heavy oils. The difference is that while in petroleum the *most desired* products are given off first, in the case of natural gas the *least desired* materials are given off first. In the first case the process consists in driving the required gases out by heating, leaving a less valuable liquid or solid residue; in the second, of driving the less valuable gases out by cooling, leaving a more valuable gaseous residue. Since the three most common gases composing the helium-bearing natural gas—exclusive of the helium gas itself—become liquid only at the low temperatures of 93°, 165°, and 195° cent. below zero, it is evident that the matter of their elimination by cooling is not so simple as might seem at first thought. This is particularly true because of the fact that the perverse helium-bearing gas is always of the type which carries unusually large amounts of the associated gas which has the lowest point of liquefaction, namely, nitrogen. Helium gas itself becomes liquid only at about 268° cent. below zero—the lowest temperature, by the way, ever reached by man. This extreme temperature, however, is not required to separate the helium gas; all that is necessary is to bring the temperature of the mixture below that of the most difficultly liquefied of the associated gases, when a helium rich mixture of gaseous residue will be obtained. As may be seen from the figures above, this will be at about 200° cent. below zero.

There are three processes by which the required cooling is accomplished, two of proven worth and a third which is theoretically superior to the others. All make use of the familiar fact that expanding air is cooled. The boy who lets the air from a bicycle tire or the man who deflates his automobile tube, know that the escaping air feels cool. This is because of its expansion under decreased pressure. The same principle underlies the manufacture of artificial ice. If, in addition, the air had been considerably chilled by being subjected to an intense cooling action before its escape, its

[1]G. Sherburne Rogers. Helium-Bearing Natural Gas. Professional Paper 121, U. S. Geological Survey. 1921.

self-cooling would have brought it to a still lower temperature. It is evident that in dealing with natural gas, each successive gas liquefied becomes a cooling agent for lowering the temperature of the remaining gases before they are allowed to cool themselves by expansion. The effectiveness of the process is still further increased if the gases are under very great pressure before being allowed to escape. So far, the process using these principles most baldly has been most effective; in the other processes a portion of the compressed and cooled gas is forced through an expansion engine and made to do work instead of merely expanding through a fixed throttle. This does away with the requirement of high pressure machinery and should result eventually in the production of helium gas more cheaply.[2] At any rate, the United States was able between the time of entering the war and the signing of the armistice to develop a successful helium gas industry. Previous scientific research had already indicated a possible source of material; the investigations of the Bureau of Mines, assistance from the National Research Council, and the coöperation of certain English companies who specialized in gas liquefaction furnished the technological skill; the Geological Survey through its investigators showed the possible extension of the productive areas; many gas companies and individuals also contributed to the desired end. It now seems probable that helium gas can be produced at a sufficiently low cost to allow of its common use for the inflation of commercial air-craft.

The length of time that the supply of helium gas will be available for commercial purposes is closely joined with a national conservation policy, for perhaps in no instance has this country been more profligate of its resources than in the case of its natural gas. Yet in connection with this resource is the only large commercial supply of helium gas known. Since, under even the most careful control, the life of a gas well is comparatively short, the value of preventing unnecessary loss is evident. As a rough approximation of the resources, Dr. G. S. Rogers estimated in September, 1918, that if every field producing at least 3 million cubic feet a day of a natural gas containing 0.35 per cent or more of helium is taken into account, a weekly production of about 6 million cubic feet of helium (not counting losses in extraction) could be maintained for two and one-half to three years. If production is held below its maximum, the life of a given supply is of course correspondingly increased. The helium of natural gas may be primordial or derived from uranium as described below.

We have referred to the changed attitude of the physicist toward the age of the earth. Strange as it may seem, this question ties in with the origin of helium. It does this through radioactivity, the property possessed by some substances of spontaneously giving off invisible rays capable, among other peculiarities, of affecting photographic plates, and of penetrating objects opaque to ordinary light. This phenomenon of radioactivity was discovered in 1896 and it was interest in its further investigation which led Madame Curie to the discovery of radium. Later patient and skilful research seems to have established several striking facts. It appears that various minerals carry the rare element uranium; this disintegrates into radium after several intermediate steps, and the radium itself eventually disintegrates into polonium—familiar to many as another rare element discovered by Madame Curie and named after her native Poland. Polonium probably disintegrates into lead, and this completes the series so far as our present knowledge goes. As these substances disintegrate they give off three kinds of "rays," one or all of which may be given off by a single substance, depending on its individual characteristics. The fact of peculiar interest to us is that *the most important rays given off have been shown to be atoms of helium.* This discovery proved for the first time the derivation of one element from another.

Since each radioactive substance breaks down at a definite and characteristic rate the ratio of helium to uranium should be greater in ancient minerals than in recent ones, and so furnishes a means for measuring geologic time. The previous method in vogue among physicists for estimating the age of the earth was to assume a certain reasonable temperature for the earth at the time of its solidification and then to calculate the length of time required for it to cool sufficiently to have the present surface temperature gradient. This method was based upon the *hypothesis* that the earth was formerly a highly heated molten body and the *fact* that it shows today a more or less constant increase in temperature as its crust is penetrated—the thermal gradient. Assuming any original temperature, it is possible to calculate how long it would take the earth to cool to the present gradient, provided there had been no later accession of heat. Several variable factors besides the original temperature enter into the problem; the best results of this method gave 20-100 million years as the age of the earth. The fact that the degeneration of the radioactive elements produces an enormous amount of heat destroyed the validity of the method on the one hand; on the other, it offered as a substitute what has been called "the most elegant method of measuring geologic time." This is because the disintegration of uranium and consequent production of helium proceed at fixed rates. From both calculation and experiment it is found that one gram of uranium will produce helium at the rate of one cubic centimeter in 9,600,000 years. The ratio between the amount of uranium in a mineral and the amount of helium present therefore allow us to calculate the age of the mineral. The amount of uranium originally present compared to that left does not enter into the problem unless extreme lengths of time are under consideration because of the fact that it is calculated to take 5,400 million years for one-half a given volume of uranium to disintegrate.

It is perfectly true that much of the helium generated may escape. The assumption is, however, that in some minerals comparatively little escapes; zircon, particularly, seems to be an effective retainer. This mineral shows very effectively the increasing ratio of helium to uranium as consecutively older rocks are examined. Recent or Pleistocene specimens from Vesuvius show an apparent age of .1 million years; Miocene specimens from the Auvergne, France, of 6.3 million. The Devonian of Norway furnishes specimens 54 million years in age, and the Upper Cambrian of Colorado specimens of 141 million years; the Archean of Ceylon, of the diamond-bearing rocks of South Africa, and of certain rocks of Ontario furnish specimens aged 286, 321 and 715 million years, respectively.

Attempts to calculate age from the ratio of uranimum to lead are of even greater significance for the reason that lead is not so likely to have been dissipated as helium. The resultant values from these calculations indicate that the Devonian rocks are 370 million years old; the rocks next younger than the Cambrian 430 million years; and the younger and older Archean rocks respectively 1,000 and 1,400 million years.

The dependability of these methods has been questioned and they are of course at best only approximations. Yet they are wonderfully suggestive as a possible means of throwing light on one of the profound questions which has interested man—the age of his dwelling place, the earth. One enthusiast in this problem says "Radioactive minerals, for the geologist, are clocks wound up at the time of their origin. After a few years of preliminary work, we are now confident that the means of reading these time-keepers is in our possession. Not only can we read them, but if they have been tampered with and are recording time incorrectly, we can, in most cases, detect the error and so safeguard ourselves against false conclusions."[3]

[2]For a résumé of the history of liquefaction of gases, together with description of the Linde and Claude processes which were used, reference may be made to Vol. III, Thorpe's Dictionary of Applied Chemistry, pp. 325-332.

[3]Arthur Holmes, "The Age of the Earth." Harpers. Reviews in an understandable way the various methods which have been employed in estimating the age of the earth.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

TESTS OF CENTRIFUGALLY CAST STEEL

THE production of metal castings by the centrifugal process may be said to have passed beyond the experimental stage; at least, in the case of certain non-ferrous metals and cast iron shapes. However, very little appears to have been published concerning centrifugally cast steel. Opportunity was given to the Bureau of Standards to examine in detail the physical and chemical characteristics of six centrifugal castings made by the Millspaugh process.

The results are interesting since they show what may be expected from such metal as compared with the product of more usual manufacturing processes. The advantages to be expected from centrifugally cast steel are physical soundness and freedom from chemical segregation and thus the elimination of waste metal to be discarded, which last is always a very important factor in other casting processes. For certain shapes forging and boring operations may be eliminated.

The investigation shows that highly satisfactory castings which are physically sound and free from serious segregation may be produced by the centrifugal method. It is shown that the properties of these castings can be greatly improved by subsequent heat treatment, the resulting metal being in a condition to compare favorably with metal that has been forged.

Technologic Paper No. 192 of the Bureau of Standards has just been issued dealing with the above subject and may be secured from the Superintendent of Documents, Washington, D. C., at 10 cents per copy.

TEMPERING OF HARDENED STEELS

A VERY thorough investigation is under way in the metallurgical division dealing with the microchanges which occur during the tempering of hardened steels. Some idea of the work involved in this investigation may be gained when it is remembered that it is necessary to take hardness measurements and make microscopic examination of all the specimens of each type of steel for each tempering treatment. Over 800 specimens are involved in the investigation and the time necessary for the mere polishing for examination is very considerable.

CORROSION OF SOFT METALS

THE results of the investigation of corrosion of soft metals have been assembled and work on a publication will soon be started. The investigation was conducted for the purpose of determining to what extent intercrystalline embrittlement occurs in the soft metals—zinc, aluminum, and tin, as a result of prolonged corrosion. The behavior of lead has previously been studied. An additional study of the last-named metal to show the accelerated influence of applied stress in causing embrittlement by corrosion was also made.

THERMAL STRESSES IN STEEL CAR WHEELS

THE investigation of stresses in cast iron and rolled steel railroad wheels has now been in progress for some time and has already been mentioned in this publication. With the aid of the results obtained from tensile tests on material taken from the wheels and thermal expansion data obtained on similar materials, computations have been made of the stresses set up by heating the tread of various steel wheels. It was found that the stresses on the outside of the wheel were in compression near the tread and in tension near the hub, the maximum value being in each case greater than the proportional limit of the material. This distribution is similar to that previously found in the single plate cast iron wheel. In order to analyze further the stress distribution in the wheels, some of them are being prepared in such a way that stress measurements can be taken on the back and also in a circumferential as well as a radial direction.

SPECTROSCOPIC ANALYSIS OF GOLD

SIXTEEN samples of standard alloys of gold were prepared for the purpose of standardizing a spectral method to be used in determining the quantities of impurities in this metal. The partial spectra of iron, copper, silver, and lead shown by these standard samples have been carefully studied and the method of making quantitative estimates of these metals from their spectra alone has been established for the range 1 per cent down to 0.0001 per cent. This investigation was undertaken for the United States Mint where the results will be used in making analyses of proof gold.

INVESTIGATION OF REINFORCED CONCRETE AND TILE FLOORS

DURING the past month work has been pushed on the preparation of a publication which will give the results of the extensive test of a reinforced concrete and clay tile floor slab which was carried out by the Bureau at Waynesburg, Ohio, and which has been mentioned before in this magazine.

This paper, which will probably be issued as one of the Technologic series, will contain information which should be of much interest and value in connection with the now important problem of reducing the cost of building construction. It is not possible to state just when this paper will be ready for distribution, but the work of collecting the data is now practically completed.

COLORLESS WATERPROOFING FOR BUILDING STONE

A PRELIMINARY report is being prepared based on results obtained in the investigation of colorless waterproofing materials for building stones, some of this work having previously been mentioned.

This report will describe the nature of the materials, the appearance of the treated stone, the depth of penetration, and the effectiveness of various preparations in preventing water absorption during a period of 6 months' exposure to the weather.

THE INVESTIGATION OF AUTOMOBILE BRAKE LININGS

A CONFERENCE recently held at the Bureau of Standards between manufacturers of automobile brake linings and representatives of the various government departments interested in the purchase of this class of material was mentioned in the last number of the SCIENTIFIC AMERICAN MONTHLY. This investigation has steadily proceeded during the past month and some important facts have been brought to light.

When one considers that the safety of automobile travel depends very largely upon the ability of the brakes to hold the car under all conditions and stop it within the shortest possible time, the importance of this work may be appreciated. The Bureau has proved beyond doubt that material to be at all suitable for this purpose should have a coefficient of friction very much higher and more uniform than is necessary for ordinary work. Extremely severe conditions of load and temperature are encountered every day and the material must be capable of standing up under them.

It appears from the investigation of many commercial brake

linings already completed that the coefficient of friction, that is, the holding power of the brakes, with some of these lining materials, may fall below one-third of its normal value the first time the brakes become hot. On cooling again, the normal condition is restored. Used linings do not show this reduction in friction to such an extent. Some lining materials will wear 10 times as long as others in the same service but the causes of such differences have not been entirely explained.

PHOTOGRAPHIC INVESTIGATION

DURING the past month quantitative measurements of sensitometer speeds, filter factors, etc., have been made with specially treated emulsions and some interesting and important information on the relative values of the different methods of treatment (washing, ammoniating, photosensitizing) as regards spectral sensitivity, total speed, fog, and keeping qualities, have been obtained. The results are now being collected and it is hoped to publish them as a scientific paper entitled "Studies in Methods of Color Sensitizing Photographic Plates."

CIRCULAR ON TELEPHONE SERVICE

CIRCULAR 112 of the Bureau of Standards on Telephone Service has just been published and may be obtained from the Superintendent of Documents, Washington, D. C., at 65 cents per copy.

The product which a telephone company sells is service but from an analytical standpoint the service as a whole must be divided into its elementary characteristics which are peculiar to the nature of the service and to the manner in which it is rendered.

The primary object of this circular is to enumerate these elements and to explain how the grade of service is dependent upon each of them. As some knowledge of the manner in which telephone service is rendered is a prerequisite for understanding a discussion of graded telephone service, the secondary object of this circular is to furnish the reader a sufficiently extensive description of modern telephone practice. This description is non-technical in character and so far as operating methods are concerned includes only those methods which are most essential. These are, however, so numerous that the greater part of the circular is given to their consideration.

Service in general is considered in the introductory section while description of the telephone plant and its operation are given in sections which respectively consider developments of the telephone art, equipment of manual systems, equipment of automatic systems, outside line construction, and telephone traffic. These are followed by the section on the principal elements of telephone service.

Attention is especially directed to the section entitled "Principal Elements of Telephone Service." Here are considered those service characteristics which are outlined in the determination of the grade of service and thus there is furnished a basis for future work along the lines of service standards. The elements are considered in groups each having common service relations and the most important factors involved in each case are enumerated and their relations to the grade of service are explained.

A section on the subject of public relations has been included to cover those phases of telephone service which receive attention by regulatory commissions both Federal and State. Plant extensions, abandonment of service, physical connections, accounting, valuation, rates, rate schedules, contracts, collections, and discrimination have been considered. A conclusion is drawn regarding the subject of service standards. The rapid and extensive development of the telephone industry is indicated by statistics given in the form of an appendix.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

IMPROVEMENTS IN NICKEL SOLUTIONS

DR. WILLIAM BLUM presented a paper before the Electro-Chemical Society at its recent meeting in which he described the use of fluorides in solutions for nickel deposition. The results which have been secured have an important bearing upon the composition of nickel solutions where an adherent deposit which shows resistance to abrasion is desired. The work is the outcome of an investigation which has led to a process for the electrolytic reproduction of engraved printing plates used by the Bureau of Printing and Engraving. It was necessary to produce surface nickel coatings of extreme hardness free from brittleness and without a tendency to curl.

In Dr. Blum's paper he discussed the general principles and the chemistry involved including methods for the control of the solution involving analysis, testing for acidity and the application of hydrogen ion measurements in this connection. There is also a discussion of the anodes used and the important bearing of the conductivity of the plating solutions. The following are the conclusions reached by Dr. Blum:

"When nickel or sodium fluoride is added to nickel baths containing boric acid, fluoborates more complex than those corresponding to the formula HBF_4 are probably produced. The fluorine content of such solutions can be determined approximately by titration with ferric chloride.

"The effect of boric acid and hydrofluoric acid upon the hydrogen ion concentration and neutralization curve of nickel sulphate solutions has been studied, and their function in plating solutions has been suggested.

"Nickel deposits produced in solutions containing fluorides have a finer structure and a higher tensile strength than those produced in corresponding chloride solutions. When prepared with anodes containing about 97 per cent of nickel, there is slightly more iron and copper in the fluoride deposits than in the chloride.

"The anode corrosion in solutions containing fluorides is good and the solutions produce less sludge than do corresponding chloride solutions. Attempts to use electrolytic anodes in such solutions at reasonably high current densities have not yet been successful, but the results with hot-rolled anodes are promising.

"The use of fluorides in nickel solutions for electrotyping will probably increase the wearing quality of the printing surface. In electroplating good deposits can be secured in the presence of fluorides at somewhat higher current densities than are ordinarily employed, and these deposits, while slightly harder to buff, show greater resistance to abrasion."

THE ESTIMATION OF COMBUSTIBLE MATERIALS IN AIR

E. BECKMANN has reported results of an investigation upon the subject of fire damp in a paper entitled "Process for Testing the Content of Combustible Materials in Air" in a German publication which has but recently become available. It is abstracted in *Science Abstracts* No. 278. The various kinds of coal and the occurrence of methane therein are first discussed. The author found that only 3 per cent of methane is necessary in air carrying much coal dust to give rise to an explosion. Previously 6 per cent of methane has been regarded as without danger. Beckmann attempted a solution of the problem determining the percentage of methane or

fire damp in air by chemical means and sought a suitable method of oxidizing methane into carbon dioxide and water in a way to adapt it to analytical purposes. Davy's lamp makes it possible to recognize as little as one quarter of a per cent of fire damp and the author discusses various other forms of testing apparatus.

The effort to devise chemical methods was unsuccessful and Beckmann then turned to a method of testing the danger of a methane-air mixture by its explosibility. The test by this method occupies about three minutes and the original paper describes a proposed apparatus and experiments which have been conducted with it including tables of results. Work has been done with an excess of oxygen and with a deficiency of oxygen. In the latter case carbon monoxide makes its appearance.

CONSTANT TEMPERATURE BATHS

In discussing some physical properties of hydrocarbons containing two or three carbon atoms Maass and Wright in the May number of the *Journal of the American Chemical Society* include a description of constant temperature baths used by them in their experiments. As many others may be working at low temperatures the following is quoted from their paper:

"Temperature baths to be constant to 0.1 degree at any particular temperature were required throughout the range of temperature from 0° to -200°. From 0° to -78° the bath consisted of ether, contained in a Dewar flask stirred by a current of dry air, the temperature being hand-regulated by the addition of small amounts of solid carbon dioxide. It was found to be advantageous to use instead of pure ether an alcohol-ether solution containing 20 per cent of alcohol. Water is insoluble in pure ether at low temperatures, so that moisture from the atmosphere condensing in the ether-bath rendered the latter opaque. Alcohol-ether solution, on the other hand, dissolves considerable quantities of water even at -80° without becoming viscous as alcohol does at this temperature, so that this bath remains transparent throughout the experiment.

"From -78° to -160° the bath consisted of the first distillate from petroleum ether condensed by use of a salt-ice mixture as cooling agent. The temperature of this bath was regulated by the addition of liquid air, as explained diagrammatically in a previous paper. Below -160° the petroleum ether became very viscous and generally unsatisfactory.

"From -160° to liquid-air temperature the bath consisted of liquid propylene cooled by liquid air. The propylene liquid is contained in a large test-tube held in a vertical position by means of a stiff wire, which is placed in an unsilvered Dewar flask containing a quantity of liquid air. It is held in position so that it may be raised or lowered at will. The propylene is cooled by contact with the liquid air and by intermittent raising and lowering of the Dewar flask the temperatures, as read by a thermometer, can be maintained at any temperature between -160° and the boiling point of liquid air to within 0.1° provided the test-tube be of thick glass and the propylene be subjected to vigorous stirring by means of a stiff steel wire. Propylene used for such a bath can be conveniently stored in a gasometer and can be used over and over again if care is taken to dry it before each condensation.

"From the boiling point of liquid air to -205° the bath consisted of liquid air in a test-tube surrounded by liquid air which could be cooled by boiling under various degrees of reduced pressure. For temperatures below -200° the air bath must necessarily be closed off from the atmosphere on account of the heat changes caused by the rapid condensation of the air of the room in its vicinity."

COLORS FOR STENCILING AND STAMPING

The following abstract on this subject is from the *Farben Zeitung*, 1921, p. 1508, by way of the *Color Trade Journal*:

"Colors used for marking packages, boxes and such like articles, also for the marking of samples and goods of various descriptions have become quite an important industry. Since their preparation does not present any particular difficulties, it is possible for small establishments to engage in their manufacture without very great installation or equipment. Most of the colors used for stamping inks, particularly where the rubber stamp method is employed, are made principally from coal-tar dyestuffs dissolved in glycerin. The coal-tar coloring matter is placed in a porcelain or enamel dish, mixed with concentrated glycerin and heated with constant stirring for a considerable time at about 200° fahr. In this preparation care should be taken not to use any more glycerin than is absolutely necessary. In order to test out the character and consistency of the ink it should be soaked into a piece of cloth and then the stamping test made with a rubber stamp. It is not possible to give a general formula for preparation of these inks as the proportions of glycerin will vary with the character of the dyestuffs used, and it is only by testing out in the manner described that a suitable proportion of the ingredients can be discovered in making up considerable quantities of such material. The glass or enamel vessel may be filled three-quarters full with glycerin, and then a water soluble aniline dyestuff is added until the mass becomes quite thick in consistency. The mixing vessel is then placed on a sand bath and heated until the boiling point is almost reached, being careful to keep the material constantly stirred. In this manner violet, green, blue, brown, eosine and coralline will be found to dissolve even in lukewarm while fuchsine requires several minutes' boiling. The resulting syrupy mass is then spread thinly on flannel or leather. Since the glycerin is practically a non-drying substance a well prepared stamping pad may be used for a year or more. According to another process a mixture is made containing 20 parts of acetic acid, 10 parts of alcohol and 70 parts of glycerin, and in this the aniline color is dissolved as before; only in the case of eosine is it necessary to substitute the acetic acid with the same quantity of water. The violet ink can be made by dissolving one part of crystalline Methyl Violet R in 20 parts of alcohol and then adding to this solution 30 parts of glycerin. In order to produce an oil free black stamping ink, 100 parts of tannic black are dissolved in a mixture of 100 parts of water and 200 parts of glycerin, and the mixture heated with proper stirring until completely dissolved. All of the coal-tar dyestuff inks can be washed out with either alcohol or caustic soda, and in order to prepare a so-called washing fast ink it is necessary to use one prepared with silver nitrate. In order to wash out this latter it would be necessary to use a solution of potassium cyanide. Washing fast black ink can be prepared by using 20 parts of copper sulfate and 30 parts of aniline hydrochloride. These are finely divided and mixed together, and then 10 parts of dextrin is added. The mixture is then rubbed up with 5 parts of glycerin and 5 parts of water until a thick, uniform mass is obtained. Another suitable black ink is obtained by using the following ingredients: 10 parts of water, 10 parts of acetic acid, 10 parts of alcohol, 70 parts of glycerin and 4 parts of Nigrosine. Blue or violet ink can be made in the same manner by using in place of the Nigrosine, 8 parts of Aniline Blue or 8 parts of Methyl Violet. Sometimes glue or gelatin are added to the glycerin and dyestuff, in which case the glue is first finely divided and then steeped in cold water before being boiled up with the glycerin and the dyestuff."

WATERPROOFING AND MILDEWPROOFING CLOTH

The Department of Agriculture in *Farmers' Bulletin* No. 1157 discusses waterproof and mildewproof cotton duck and gives formulæ which are designed solely for waterproofing and mildewproofing treatments. Of the several existing types of waterproofing processes five general classifications can be made: (1) Those in which the water resistance is due to insoluble metallic soap; (2) those which depend upon wax such as paraffin; (3) those which use such bituminous materials as asphaltum or tar; (4) those employing drying oils

such as linseed oil and, lastly, various combinations of these other types.

Following the investigations, these four formulæ have been advocated as meeting the requirements of those using canvas for outdoor purposes:

FORMULA 1

	Pounds
Amorphous mineral wax or crude petrolatum	7½
Yellow beeswax	1
Refined Bermudez Lake asphalt	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 2

	Pounds
Petroleum asphalt (medium hard) or Bermudez asphalt	6
Neutral or extracted wool grease	2½
Lead oleate, technical	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 3

	Pounds
Amorphous mineral wax or crude petrolatum	8½
Yellow beeswax	1½

Solvent: 3 gallons gasoline and 2 gallons kerosene.

FORMULA 4

	Pounds
Amorphous mineral wax or crude petrolatum	6½
Yellow beeswax	1½
Lead oleate, technical	2

Solvent: 3 gallons gasoline and 2 gallons kerosene.

Applications of mixture made by formulas 1 and 2 give the canvas a dark brownish color, while those made according to formulas 3 and 4 give it a light buff to khaki color. The first two are preferable for all purposes where a dark color is not objectionable.

The amphorous wax referred to is very similar to petrolatum and is a by-product in refining chilled cylinder-oil stocks. The Bulletin discusses certain substitutions that can be made with propriety and indicates where the more unusual materials named can be obtained. Of course in all instances precautions must be taken during mixing to avoid fire.

In applying these mixtures a brush may be used or where large surfaces are involved a spray pump operated at a pressure of at least fifty pounds can be used to advantage notwithstanding some loss of material which accompanies this method. The experience has been that one coat applied to one side of the canvas is usually sufficient. This will increase the weight of the material from 3½ to 4½ ounces per square yard and ten pounds of material with five gallons of the solvent will ordinarily treat about forty square yards of canvas.

INK CONSIDERED HISTORICALLY

The *American Dyestuffs Reporter* gives the following interesting items with reference to the history of ink:

"Ink, considered from a historical standpoint, is extremely interesting, samples of Egyptian writing, which are still plainly legible, having been produced as early at 2500 B.C., while it is generally conceded that other specimens of papyri date back to at least 3500 B.C.

"The ink used by the earliest writers undoubtedly consisted of a carbon base prepared either by burning wood or animal matter, after which same was ground to a fine powder and properly combined with oils and gums, and probably oftentimes thinned with water to the proper consistency for writing.

"'India ink' was invented by the Chinese about 1200 B.C. and was prepared by mixing a very fine soot with a gelatine prepared from asses' skin.

"The greater number of documents which have come down to us from the medieval times were written with 'India ink.' Owing to the permanent character of writings made with 'India ink' there is still a very strong tendency to use this type of ink in many modern documents. While 'India ink' has no tendency to disintegrate with time, it can be obliterated if treated with water.

"Tannin-iron inks were introduced into Europe from Arabia during the early part of the twelfth century.

WRITING MATERIALS

"Papyrus, vellum and parchment were the earliest forms of material upon which ink writing was practised.

"Papyrus was largely used by the early Egyptians and many perfectly preserved specimens have been found in the pyramids of the Pharaohs. Papyrus was prepared from a form of reed which grew luxuriantly on the banks of the Nile.

"Vellum was prepared by the proper treatment of the skin of calves, while parchment was prepared from the skin of the sheep.

"The materials used for applying the ink to the paper consisted at first of reeds and brushes, and later the stylus pen. During the sixth century the quill pen came into existence and its use was continued for centuries.

"Steel pens first came into regular use in 1803, and ever since that time the makers of the steel pen have been endeavoring to duplicate the desirable qualities of the quill pen."

ASPHALT ANALYSIS

H. J. Rossbacher, in the June *Chemical Bulletin*, discusses the interpretation of asphalt analyses. Asphalt analysis consists principally in the application of a number of empirical tests designed for the purpose of measuring the consistency of the material and for determining its source as well as the degree of skill that has been exercised in preparing a particular product for its purpose.

The tests applied for consistency and sensibility to temperature are penetration, viscosity, melting point, and the float test. In routine work, penetration is determined at 25 deg. cent. with a load of 100 grams, and a time interval of five seconds. The depth in millimeters to which a weighted needle sinks into the sample under the conditions of time and temperature mentioned, is called penetration. Viscosity is determined with the Engler viscosimeter and for those asphalts which are too soft for the penetration test and yet too viscous for the viscosimeter there has been developed the float test. This value is the time required to melt out a cylinder of the material from a collar screwed into a metal bowl and floated in warm water. By standardizing the temperature of the sample cylinder or plug at the start and the temperature of the water, tests are reproducible within two seconds. The melting point is determined according to the methods described by the American Society for Testing Materials.

Other tests are the determination of ductility which indcates the relative cohesion of the various materials of a given consistency, fixed carbon, the flash point, evaporation loss, and specific gravity. Solubilities are determined with carbon disulphide, carbon tetrachloride and 88 deg. naphtha. The result of the first test gives the bitumen content and the difference in solubility with disulphide and tetrachloride is usually interpreted as an indication of the extent to which the sample has been weathered or perhaps overheated during compounding. Solubility in naphtha serves to indicate the type of material. As the author says, "It is probable that no type of material is made the subject of wider or more unsubstantiated claims than is asphalt. Asphalts consisting as they do of colloidal combinations of organic compounds of unknown composition continue to offer a verdant playground for the imagination of the promoter and salesman. There is a need, therefore, for scientific investigation of the properties of asphaltic materials and the chemist who is called on to pass on the properties of a particular compound for a given purpose should 'maintain an attitude of healthy skepticism.'"

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

DIRECT RESEARCH AND DIRECT RESULTS

With the depression of trade prevailing at the moment the tendency is to cut down expenses; but insufficient distinction between expense and expenditure is often falsely called economy, and, according to G. A. Percival, writing in *Beama* for June, 1921, money spent on properly organized research is investment. As Disraeli expressed it: "True economy does not consist in reckless reduction of expenditure." Expenditure in the right direction leads to efficiency, and efficiency is the truest form of economy.

The author first discusses the necessity of research. Cheap living is the key to national prosperity, and this becomes possible with improvements in machinery and manufacturing processes. He then takes the aversion of the average business man to invest his money in research. The word "invest" is used deliberately, as all research, if carried out properly, is investment and not speculation; it is in fact a gilt-edged security. He cites the firms of Brunner Mond in England, the G. E. in America, and Krupp in Germany as organizations which have been built up on research. In fact the largest manufacturing concerns in every country have been developed on the same principle.

The functions of research workers may be classified as pure and applied, or direct and indirect. Pure or direct research can be engaged in only by the largest corporations or by the coöperation of several smaller manufacturers, but the various institutions for carrying on investigations of a purely scientific nature rely, to a large extent, upon the generosity of industrial concerns interested in a similar class of work. Although such research is often apparently tedious and useless, it eventually plays its part and returns a handsome interest.

In the control or routine work the research is largely a question of "looking for trouble." A "soft job" while all goes well, but "there to be kicked" when things go wrong. It is a department recognized by a firm of any standing as of as much importance as the accountants. Every manufacturing operation has several processes, and quite apart from any question of testing incoming and outgoing material, the precision of operations is as vital as the perfect circulation of the blood in a human body. A small change, an error overlooked will creep into the heart and the poison will require time and care to eliminate.

While care in selection of material is of prime importance, in many factories the mistake is often made of confusing process work with material control. They are links in the same chain and of equal importance, but they are distinct. Both these sections, however, are indirect research, inasmuch as the continual accumulation of data, the effects of slight variations in material and methods, are collected and are available for further development. A slight change due to unforeseen circumstances often gives extremely interesting results, which, if carefully followed, may lead to entirely new methods. Such changes must be followed in detail and the effects throughout manufacture studied before being put into operation. Because work of this kind is of a definitely commercial nature it is indirect research, as distinct from absolute research.

After indicating some ways of financing and coöperating the efforts in pure research the author concludes thus: "The object of pure science is to advance knowledge; that of applied science to obtain financial benefit, but the first may prove a greater financial asset, while the latter may develop only much theory on the subject. They are complementary to each other and must be fostered and developed together."

OZONE "PURE-AIRIFIER"

This is a new type of ozonator which effects a saving of fuel in ventilating work. This saving is based upon the difference in temperature between the outside air and the used interior air, which can be recirculated after ozonation with considerable less addition of heat. An assembly of twenty-five units has a capacity of 25,000 cu. ft. of air per minute. A rheostat is used to control the degree of ozonation, and a step-up transformer gives the necessary high voltage.

The construction of the unit consists of a smooth electrode of aluminum which slips into a cylinder of Pyrex glass, the glass acting as the dielectric. The exterior electrode is a sheet of aluminum, expanded to form a number of small points, and then bent into cylindrical form to fit around the glass cylinder. All conducting wires are made of aluminum. The advantage claimed for this type of construction is that the discharge is a continuous static glow discharge, rather than crackling electric spark, thus eliminating the formation of nitrous oxide. The power consumption is low, being 120 watts for the twenty-five unit system running at capacity.—*Heating and Ventilating Magazine*, March, 1921. Through *Sibley Journal of Engineering*.

THE LONGEST SUBMARINE TELEPHONE CABLE

East Prussia has been separated from the German mainland by a wedge-shaped territory assigned to Poland. To obviate international difficulties from overland telegraph and telephone lines, Germany decided to lay a submarine cable, bridging by sea the Polish wedge. This submarine telephone cable to East Prussia is the longest in existence, having a length of 170 kilometers. The cable contains six telephone pairs and three single telegraph wires. Each of the twelve telephone wires is covered with a double layer of annealed iron wire. All conductors are paper insulated. Owing to a depth reaching 110 m. at its greatest point, a double lead sheath, a double spiral of steel wire and finally an outer interlocked steel armoring have been used. Each 1½ miles a water stop has been built into the cable to localize any entrance of water into the cable in case of break. The over-all diameter of the submarine cable is about 2 inches and its weight is 8 pounds per foot. The manufacturers delivered the cable in three lengths (21, 77 and 77 km.). A 1,000-ton freighter with a modern paying out machine mounted on its stern was used and finished the work in two trips of sixteen and thirteen hours' actual laying time.

The required guarantee data for one kilometer of telephone line, alternating current, 800 cycles and 150 deg. cent. were: Effective resistance, 12 ohms; self-inductance, 0.009 henries; mutual capacity, 0.052 mfd.; specific damping, 0.015; insulation resistance, 2,000 megohms.

The author gives a complete account of actual test methods and results obtained by the postal authorities at the final inspection. The telegraph lines operate with Siemen's rapid telegraphs, and vacuum-tube amplifiers are used for the telephone lines.—*Elektrotechnische Zeitschrift*, April 7 and 14, 1921. Abstract, *Electrical World*, June 18, 1921.

CARRIER CURRENT TELEPHONY AND TELEGRAPHY

A very exhaustive paper on this subject appeared in the *Journal of the American Institute of Electrical Engineers.* The authors of this paper are Messrs. E. H. Colpitts and O. B. Blackwell. The final part of the paper will be found in the June issue of the above-mentioned journal; it is accompanied by a bibliography covering the period of 1867-1921.

It is interesting to note some of the conclusions reached by the authors: The carrier telegraph and telephone systems are designed to fit as an integral unit into a comprehensive wire plant, the relay-circuit arrangements providing for automatic repetition between the carrier channels and the connecting circuits, whether the latter be subscribers' loops or an additional section of long-distance circuit. The carrier telegraph circuits are used in the Bell plant, as are the regular composited Morse circuits, to furnish leased-wire service. The requirements for this service are particularly exacting as regards continuity and quality. The carrier telegraph circuits have proved to be very satisfactory in meeting these demands.

Carrier telephone systems—at least in the present state of the art—are economical in a general public service communication system only for use over relatively long distances. Of course, whether carrier systems can be justified in any given case depends upon factors peculiar to that case; in some instances, for example, it may not be physically possible to provide additional wires over a given toll line or cable route, in which case the relatively high apparatus costs may be easily justified. The carrier telegraph system is also essentially a long-distance proposition, although it is sometimes possible to warrant its use for distances somewhat shorter than in the case of telephone systems.

Another paper on the same subject was contributed by Chas. A. Culver to the March, 1921, issue of the *Journal of the Franklin Institute*. It deals primarily with the system of multiplex telephony invented by General Squier. It is defined as that of high-frequency electrical resonance, combined with the use of an integrating translator which delivers to the telephone receiver a varying unidirectional current corresponding to the voice current supplied to the modulating device at the transmitting station. The development of the three-electrode tube with its repeating, amplifying and modulating properties, and more particularly its qualities as a high-frequency alternating current generator, made possible the wide application of the guided-wire system. In the Squier system several such transmitting organizations with suitable frequency intervals are bridged across a physical telegraph or telephone circuit, each organization corresponding to a similarly tuned receiver at the other end. Thus, several and independent conversations are made possible over one pair of wires.

The number depends somewhat upon the electrical constants of the line and also upon certain inherent limitations which are discussed. A frequency difference of at least 20,000 must be allowed between sets. Frequencies up to 500,000 and down to 15,000 may be used, allowing for the elimination of the "beat notes" this would permit of at least six guided-wave two-way conversations in addition to the ordinary line conversation. It is asserted that the number of super-imposed conversations may soon be doubled. The author has designed a new circuit in which the high-frequency oscillation tube also serves as a detector and is used both for transmission and reception; furthermore no energy is delivered to the line except when one speaks into the microphone.

It is possible under certain conditions to operate high-frequency super-channels over adjacent parallel circuits, say, on the same pole, without cross talk. Copper, copper-clad iron and aluminum wire will serve for carrier circuits, but not galvanized iron. It is an important fact that high-tension power transmission lines may be utilized by electrostatically coupling the high-frequency equipment to the power line through suitable high-tension condensers, or by its direct connection to a wire a few hundred feet long supported parallel and close to the power wires. There is no interference from power circuits. There is a possibility of interference from radio stations, but this may be obviated by avoiding the neighborhood of their frequencies. Statics are less serious than in ordinary radiotelephony. The advantages of the guided wave systems are summarized as better voice reproduction, greater secrecy possibilty of maintaining communication even when wires are broken, flexibility, possibility of communication with moving trains and finally, in its main application to the extension of the traffic capacity of the existing lines.

A FUSE IN UNEXPLOSIVE OIL

THIS paper describes in detail a type of fuse which can be used on circuits up to 45,000 volts, with maximum rupturing capacity of 13,500 kva., with sectional drawings and photographs. As this piece of apparatus is very compact and small for its capacity, it represents a distinct advance over the older types.

It consists essentially of a porcelain oil-tight grip container, held in the usual form of contacts, the oil level being three-quarters of the way up; the fuse wire itself is held between two screws, above the level of the oil; the lower screw being movable and contained in, but insulated from, a metallic cylinder, divided into two chambers round the base of which are holes below the level of the oil connecting with the porcelain container.

In the event of a short circuit causing the fuse to blow, the lower screw is forcibly blown downward into the oil by the pressure, thereby breaking the arc very quickly. Any excess pressure is taken by the oil, which is able to percolate to the outer porcelain casing through the holes mentioned. All the pressure is therefore taken by the upper half of the metallic cylinder, and there is none on the porcelain itself.

To replace a fuse, the whole of the metallic portion can be removed from the porcelain, leaving the latter clear, and therefore easy to clean, while the screws and fuse wire can be easily replaced in a few minutes.—P. Charpentier, *Revue Générale de l'Electricité*, Jan. 1, 1921. Abstracted by *Technical Review.*

SOME TRANSMISSION LINE TESTS

IN view of the tendency in this country to adopt the 220,000-v. pressure as the standard for long distance transmission the corona loss tests which were recently made by W. W. Lewis should be of considerable interest. The tests were made on a transmission line 101.5 miles long, extending from Junction Dam to Grand Rapids and also on the additional 47.3 miles extending from Grand Rapids to Kalamazoo. The details of the transmission lines, methods of tests and of the results will be found in the *Journal of the American Institute of Electrical Engineers* for June, 1921, pp. 492-506. The following conclusions were arrived at:

Corona losses at approximately 210 kv. at the generating end and 225 kv. at the receiving end of a 100-mile line of 110,000 cir. mil. conductor have been recorded.

The losses in general follow Peck's law, with some deviation especially at the lower voltages, where the tested loss is as a rule less than the calculated.

A current in the grounded neutral was encountered which at the higher voltages was about 40 per cent of the line current. This current begins at about the normal line voltage. It is apparently due to the corona which causes a pulsation in the voltage wave and a triple-frequency current to flow through the capacitance to ground and back through the grounded neutral.

The line charging current, the current in grounded neutral and the rise in voltage along the line are all greater than calculated from the geometrical capacitance. This may be accounted for by an increased capacitance due to increased diameter of conductor caused by corona. Harmonics introduced into the voltage wave by the corona may contribute to the effect noticed.

The tests indicate a difference in corona loss with the neutral grounded and isolated, probably due to the flow of triple-frequency current in one case, and the distortion of voltage by triple-frequency component in the other.

The tests brought out the danger of overvoltage across legs and between neutral and ground with γ-γ connection. They

also clearly indicate the desirability of operating a transmission line below the corona voltage, thus avoiding corona loss and its accompanying effects.

DISCHARGE THROUGH AN ALUMINUM-CELL LIGHTNING ARRESTOR

The aluminum cell is believed to be most nearly ideal for protection of extra high-tension transmission systems, but very little is known of the conditions of breakdown or discharge. The electrode surface is covered with an O_2 gas film partly converted into AlO_3; outside the gas layer there is a slimy film of $Al(OH)_3$. Thus a series of resistances and capacities are formed. Experiments were carried out to obtain the dynamic characteristic (curve of instantaneous voltage vs. amperage) of the discharge, especially at higher frequencies. The curve is nearly an ellipse at 250-1,000 cycles per second. Interpretation of the characteristics of these frequencies shows very desirable qualities for lightning arrestors: (1) The condenser action of the film makes the charging current increase with frequency; (2) the discharge has less tendency to current recurrent surges; (3) reforming the film takes an appreciable time so that the discharge current may continue without disruptively puncturing it.—*Tohoku Imp. University, Technology Reports*, Vol. 1, pp. 161-176, 1920. Through *Chemical Abstracts.*

HYDROELECTRIC DEVELOPMENT IN ITALY

The high initial cost of hydroelectric development, the uncertain restrictions placed upon such development by states and government and similar factors have retarded the development of the smaller water powers in the United States. Where coal prices are high and other conditions more favorable the possibilities of replacing the energy derived from coal by that derived from the waterfall is being fully realized. Italy has been making rapid progress during the last few years. In 1915 her electric power resources were estimated at 2,500,000,000 kilowatt hours per annum. This figure had been increased to 3,700,000,000 before the end of the war and approaches 4,000,000,000. The capital invested in these hydroelectric power companies has reached now 1,500,000 lire. In the years from 1915 to 1920, 265,000 hp. was added and plants now under construction are expected to add 400,000 more. Hydroelectric power has a direct influence not only upon those industries requiring power merely for the turning of wheels but particularly upon those chemical industries where high temperatures under exact conditions are desired or where electric current itself must be employed.

MAGNETOS FOR IGNITION PURPOSES IN INTERNAL COMBUSTION ENGINES

At the beginning of the war Great Britain was cut off of the magneto supply and was compelled to develop its own magneto industry. The paper by Mr. E. A. Watson on Magneto Design which was recently read before the Institution of Electrical Engineers proves that the British engineers have made much progress in this direction.

The author discusses at length the electrical as well as the mechanical problems involved. Electrically the magneto may be considered as a high tension alternator in which a special artifice is employed to obtain a rapid movement of the flux relative to the armature winding at one particular instant, while keeping the armature speed at a low figure. This is effected by using a portion of the revolution so that the currents induced in it tend to prevent any change in the flux leaving it and consequently produce distortion in the magnetic field. An interruption of the primary circuit cuts off this distorting current with the result that the magnetic flux rapidly returns to its original value, causing a high pressure in the secondary, which leads to spark passing between the points of the plug. These considerations necessitate that the value of BH should be as high as possible, and the curves connecting BH and H are therefore important factors in choosing the type of permanent magnet and the material employed in its manufacture. Great use is made in America of chromium steels which will give a (BH) max. of 240,000 to 250,000. Recently, however, the range has been extended by the introduction of the new cobalt steels as developed by Professor Honda and Sir Robert Hadfield. With 35 per cent of cobalt, values of (BH) max. as high as 900,000 can be reached, the value of Brem being from 10,000 to 10,500 with a value of HC of about 200 to 240. Such a steel is naturally expensive, but a much smaller amount is required. The higher coercive force opens up possibilities of simplification of design, owing to the permissible reduction in magnet length.

The author discusses at length the theoretical questions of the effect of armature reactance and resistance, the transformation of magnetic to electrical energy, the effect of the condenser and the choice of capacity. He summarizes the results of his reasoning as follows: 1. *Low-speed voltage.*—Dependent upon available magnetic energy, primary resistance, speed of rotation, number of secondary turns, energy losses and condenser capacity. Increases with increasing speed up to a limiting value, which increases with increase in available magnetic energy. 2. *Utility.*—At high speeds proportional to magnetic potential of distorted field and inversely proportional to number of secondary turns. At low speeds dependent upon speed and primary resistance. 3. *Energy in initial spark.*—At high speeds proportional to available magnetic energy. Dependent upon losses in iron of armature, etc., and partly on condenser capacity. If losses were absent the energy would be independent of voltage, but, owing to their presence, the energy decreases as the voltage is raised. At low speeds it is dependent upon speed and primary resistance. 4. *Total energy in spark and flame.*—This follows the same law as the energy in the initial spark, but is greater in value. Theoretically the total energy may be twice that in the initial spark. This energy is approximately that stored in a magnetic field of value 2B at a potential of H and is, therefore, $2BH/8\pi$ or $BH/4\pi$. If, instead of allowing this field to collapse suddenly, we do work on it, maintaining the potential H until $B = O$, additional work $BH/(4\pi)$ will be done upon the field, and the total available energy will be $BH(2\pi)$. 5. *R.M.S. value of current in secondary circuit.*—Depends upon characteristics of magneto itself and also upon spark-gap resistance. A magneto may be made to give almost any reading desired upon an ammeter, by altering the constants of the circuit. In particular, adding capacity to the terminals will increase the reading several fold.

The following points form the basis of development in magneto design: (1) Improvement in material available, including the use of cheaper but equally effective substitutes; (2) better utilization of existing material; (3) improved mechanical design, tending to longer life and greater reliability in service; (4) simplification of parts, reducing cost of construction and elimination of difficult manufacturing problems.

In some cases these points are to a certain extent incompatible, notably (2) and (4), and a compromise has to be effected. The use of the new cobalt steel instead of tungsten steel has already been noted. Much might be done in the production of a satisfactory substitute for platinum for contact points. Tungsten is certainly not equal to platinum, having shorter life and much higher contact resistance.

Under heading (2) the author describes the use of laminated instead of solid pole-shoes. Much might be done in the direction of improved insulating materials and methods of insulation, so as to enable a better space factor to be obtained. There is room for improvement in the magnetic circuit. Examination of the armature reaction shows that certain portions of the ordinary horseshoe magnet are extremely ineffective. Under heading (3) great progress has been made, particularly as regards the contact breaker and its actuating cams. Under heading (4) much has been accomplished of late by the use of die castings, produced both in aluminum alloys and in alloys with a zinc base.—*Electrician* (London), Vol. 86, 476-477, 482-484, 487-489, April 22, 1921.

Progress in Mining and Metallurgy

Abstracts of Recent and Coming Papers

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

MAKING A 5 PER CENT NICKEL-CAST-IRON ALLOY IN AN ELECTRIC FURNACE

By D. N. Witman

One of the special uses to which the electric furnace has been put recently is the melting of an alloy of nickel and cast iron for the production of electrical-resistance grids. The metal sections of these grids are quite uniform for each pattern, but there is, among the various patterns, a variety of thicknesses. The cross sections vary from ½ by 3/16 inch to as small as ⅛ by ⅛ inch. The electrical resistance of a perfect casting lies within 10 per cent above or below the fixed listed resistance for each pattern. Good molding is essential to success in the making of these grids, for with absolutely correct metal, a variation of 0.01 inch in width and thickness of section on some of the patterns may mean as much as 12 or 14 per cent variation in resistance.

The service for which these castings are intended demands that the metal, even in the smallest castings, be very soft, showing an open, gray, highly graphitic structure in order that they may be resistant to shock and stand up well under rough usage. The metal used for this purpose is a gray iron alloyed with 4 to 5 per cent of nickel, which element, when the composition of the alloy is correct, imparts toughness and pliability to the metal and helps to overcome the tendency of metal to run white and become brittle because of the rapid cooling action of the sand mold. When cold, these castings can be twisted into various shapes, taking a permanent set without breaking. The alloy has approximately double the electrical resistance of ordinary cast iron.

On account of the nickel content of the metal, which raises the setting point of the alloy considerably above that for cast iron, causing the alloy to be sluggish at a temperature at which cast iron would have great fluidity, it is necessary to cast at a much higher temperature than would be required for cast iron. The temperature of the metal in the ladle, as determined by a Leeds & Northrup optical pyrometer, runs between 2,800 and 2,900 deg. fahr.

The required amounts of pig iron, scrap, and nickel ingot, together with some retort carbon, are charged into the furnace, the power turned on, and the melting done as quickly as possible. The melting down is carried on at the higher of the two possible voltages, viz., 110 volt, and the input of current fluctuates from 0 to 3,000 amperes per phase; the melting requires 1 hour to 1 hour and 10 minutes. If there is an accumulation of slag on the metal, because dirty metals were used in the charge or because some of the bottom has come up, it is skimmed off.

As there is not enough time to allow for chemical determinations, the necessary adjustments are made from observations of test pieces, so shaped as to indicate the character of the metal as cast in all sections from a feather edge up to ½ inch.

One of the peculiarities of this alloy of cast iron and nickel is a rejection of graphite from the metal when it is just melted, but when the metal is superheated it again takes up the carbon thrown out at a lower temperature. It is this property of nickel, throwing out graphite on cooling, that helps to make the grids soft and gray in the smaller sections and incidentally keeps the electrical resistance high.

The average power consumption, covering a 9-month period of operation, was 1,100 kw-hr. per ton, while the electrode consumption for the same period averaged 28 pounds per ton. These figures are rather high even for such a small furnace, but considering that the operation was, in a sense, experimental, and the installation more or less a makeshift, it is probably not as bad as the figures would seem to indicate.

The advantage of this method of melting may be stated briefly as follows:

There is no picking up of sulfur in the melting process, therefore all of the scrap alloy, such as gates, sprues, defective grids and over iron can be charged back into the furnace and nothing wasted. In fact, it is quite possible and just as easy to run a heat of 100 per cent scrap as it is to run one made up of pig iron, scrap and nickel.

The possibility of adjusting the metal to the proper composition while it is in the furnace.

The attaining of the high temperature necessary to cast the metal into very small section castings so that it will run clean and remain gray and tough.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

ANTHRACOAL—A NEW DOMESTIC AND METALLURGICAL FUEL

By Donald Markle

Anthracoal is a mixture of small particles of anthracite coal and a matrix of practically pure carbon formed from the distillation of coal-tar pitch or other suitable bitumen. It is a hard, dense, homogeneous mass, with a silvery luster and, in color, varies from silvery to grayish black. When pushed from the oven it develops only partly the fingerlike structure of coke; but, unlike coke, it has a tendency to remain in blocky masses. When struck with a hammer or passed through crushing rolls, it breaks with an irregular fracture, similar to anthracite, but with very little fines. Due to its density, anthracite is harder, tougher, and stronger than coke.

Anthracoal can be made in a coke oven upon the same large scale as bituminous coke and can be produced with little greater expense; therefore it should prove a tremendous factor in utilizing the anthracite culm now going to waste.

The percentage of pitch used varies somewhat with the pitch, the character of the culm, and the method of mixing and grinding the material. In the tests at Syracuse, two grades of pitch were used, one with a melting point of 265 deg. fahr. and one 280 deg. fahr; both worked well. The amount of pitch used varied between 14.8 and 25 per cent, due to the method of proportioning. Ovens that contained 15 per cent pitch and 85 per cent culm, by weight, gave an excellent anthracoal and pushed readily. Ovens that contained 25 per cent pitch and 75 per cent culm also gave an excellent anthracoal but more of a thick carbon scale was noted in the ovens than when the mixture contained less pitch; also, the anthracoal was more porous than that made from the 15 and 17 per cent mixture. After many tests, both in the coke ovens and in the laboratory, it was found that between 16 and 17 per cent produced the best anthracoal with minimum fines and scale. Using below 16 per cent pitch, the anthracoal showed signs of attrition and not holding together, while above 17 per cent the surplus pitch flowed to the sides of the retort and produced a carbon scale that made a great deal of fines when pushed on to the dock.

A direct comparison between chestnut size of anthracoal and chestnut size of anthracite coal was made by an eight-day test of each in a kitchen range. The range performed the same service in each test, cooking three meals a day, heating water in the boiler, and, in fact, doing exactly the same work in each case. Observations were made as to amount of fuel fired each day, the amount of ashes produced, and the posi-

tion of the drafts during each run. The fire was started with wood at the beginning of each test and allowed to burn completely out at the end of the eight days. The fire was dampened at night and between meals with equal ease with the anthracoal and anthracite.

The total fuel consumed in each eight-day test was 288.5 pound anthracoal and 346.52 pound of anthracite, or 20.1 per cent more anthracite than anthracoal. As exactly the same service was obtained from each fuel, the results show that in this range the chestnut anthracite was 20 per cent less efficient than the anthracoal of the same size.

The evidence and data submitted thus far appear to point to a plant of regenerative non-recovery ovens; that is, a plant where the gas is brought directly from the charge into the flues and regenerative apparatus of the oven instead of passing through cooling coils and other apparatus for abstracting the by-products before it is burned.

The reasons for doing this are as follows:

1. If the gas is cooled first the sensible heat will be lost.

2. Removal of the by-products will lessen the heating value of the gas.

3. The by-products in the anthracoal gas are about one-third to one-half those in the bituminous gas, so that it is doubtful, with the uncertain and changing market, whether the recovery of the by-products would be worth the expense of the by-product apparatus which, in cost, represents one-half the cost of the ovens.

4. A non-recovery oven of the regenerative type will burn the gas direct, have the benefit of the sensible heat in the gas as it comes off the charge, and also have the additional heat value of the by-products which are not removed.

5. The ovens should prove to be self-sustaining and have ample gas for an exceptionally hot retort and quick coking in the non-recovery type.

6. A non-recovery type oven operating with anthracoal should produce 79 per cent more anthracoal in 24 hours than the same type of recovery oven. As the cost of manufacture in each case is almost the same with perhaps a little greater expense involved in the preparation of the anthracoal mix, the 79 per cent greater production of anthracoal than coke in 24 hours more than offsets the loss of the by-products.

7. A non-recovery type oven should prove more adaptable to the anthracite region. Its cost will be less to construct than the recovery type, and it will not require a skilled staff of chemists and workmen.

8. No market need be developed or additional sales force required, as in the by-product game, but rather the maximum amount of fuel can be produced, which can be handled in conjunction with the sale of anthracite coal.

Naturally, the success of the anthracoal will not be proved until a plant has been erected and the ovens operated on a commercial scale for a period of time. As a non-recovery regenerative oven has been rarely used in this country it will embody some changes in design from the regular regenerative type. However, this type of oven has been used with success in Germany and never presented any difficulties, as far as can be learned.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

ANALYSIS OF SOME DRILL-STEEL TESTS

By Francis B. Foley

The responsibility for rock-drill failures does not rest entirely on the smith. Little has been published concerning the efficiency of drill steel, though the *Canadian Mining Journal* published the breakage record of a large number of hollow drill steels. This record indicates that most of the breaks occur during the early life of the steel and that as a given batch of steel is used, its percentage of breakage decreases. This fact, the article points out, is at variance with the much-talked-of theory concerning failure from crystallization and fatigue. It seems to point to the fact that the greater part of drill-steel failure from breakage is traceable to faulty manufacture, resulting in defects in the bore of the hollow steel from inclusions of slag or oxides, etc. As this defective material meets with early failure, it is weeded out. In addition, some breakage may be caused by a lack of proper condition with respect to heat treatment of the steel as furnished by the manufacturer.

In the article mentioned, the breakage of 1¼-inch hollow steel is given as 4.62 per cent for the early period of use, with a decrease to 3.35 per cent and 2.67 per cent with time in use. For 1-inch hexagonal hollow steel, the figures for breakage are 0.18 per cent, and 0.06 per cent; attention is called to the "enormous decrease in breakage by the use of smaller diameter drills." The figures are given as so many "drills sharpened," but there is no way of determining the percentage of tools broken, which must be considerably higher. For instance, from May 10 to August 9, or three months, there was a breakage of 2,883 drills out of 85,882 drills sharpened, which means an average of 32 broken steels per day out of 954 steels sharpened per day. Of course, some of these broken steels are made into shorter drills and are not lost, so that it is impossible to determine, from the figures, what the true percentage of drills broken was. The figures are from records of a total of over 190,000 tools sharpened.

BREAKAGE CAUSED BY FAULTY PRACTICE IN FORGING AND HARDENING

Breakage near the shank and bit ends of the steel is caused for the most part, by faulty practice in forging and hardening. Undoubtedly, the length of the steel, the kind of drill, and the difference in conditions existing in the testing of steel day by day have some bearing on the question of drill-steel failures. However, no steel has been consistently favored or penalized with respect to these variables.

LOCATION OF BREAKS IN DRILL STEELS

The total breakage is given in tables. A division is made of breaks that occurred within 10 inches of the bit end, within 10 inches of the shank end, between points 10 inches from either end but nearer the bit end, and between points 10 inches from either end but nearer the shank end. There was a total of 253 breaks, of which 173, or 68.4 per cent were in the half of the steel with the shank and 80 per cent in the half with the bit; 68 per cent of the breakage in the middle section of the steel was nearer the shank end than the bit end. That breakage is more prevalent in the half of the steel nearer the drill is to be expected when it is considered that, while the bit end is left free to yield, under the bending and vibratory stresses applied, the shank end is held fairly rigid in the drill. The tables show that about 90 per cent of the total breakage occurred within 10 inches of the ends of the steel; in other words, in the portion of the steel heated for forging. Some of this breakage may be said to be caused by fatigue, but the existence of such a phenomenon in steel is doubtful and is denied by many investigators.

In order to get a better idea of the location of breaks at the ends of the steel, a curve has been plotted. This curve has been derived by plotting at the even inch, breaks that occurred within ½ inch of that point. The position of maximum breakage in the tools is shown by the sketches of the shank and bit ends. The different steps taken in forging and hardening the steel are given in order that the full value of this curve may be appreciated. The shank end is considered first. When a collar is necessary, which was not the case in the tests under discussion, the fresh steel is heated for about 6 or 7 inches from the end and the collar is forged by upsetting. The condition of the metal at the farthest point of heating undergoes a rather sharp change from the annealed structure of the original material to a structure produced by the cooling from the forging temperature. The shank is then reheated for a distance, which probably varies up to 7 inches from the end, to a temperature above its critical range, but probably below the temperature for forging, and is plunged in oil. There is, then, a change from the annealed to the oil-quenched condition. When a lug or collar is forged there

may, therefore, be a number of structurally different zones, depending on the length of the steel heated for hardening; namely, the original structure of the bar, that produced in the cooling of a part of the bar heated for the upsetting operation but not worked, that produced in the upsetting, and, finally, the oil-hardened structure of the end. When it is realized that, while the shank end of the steel is supported in the chuck of the drill, the shaft of the steel outside the drill is subjected to considerable vibratory and bending stresses, the stresses that this heterogeneous region is expected to withstand will be appreciated. It is no wonder that most of the failures from breakage are found in this region.

Much the same kind of operation is undergone by the bit end of the steel. About 4 inches of it is heated for forging, and afterward only ½ to 1 inch is heated for quenching in water. Here, again, there are probably three zones of structurally different material.

To summarize, drill steel should be in the best condition when received from the manufacturer, free from imperfections of a mechanical nature and from impurities; it should also be in the best annealed condition to withstand the vibration and shock its service will entail.

There is, for a given steel, a temperature and a rate of cooling from this temperature that will produce the conditions that will best withstand the stresses of shock and bending.

Lack of uniformity in performance shows a lack of uniformity in the heat-treating operations, which may be overcome by the devising of means, of an automatic or "fool-proof" nature, that will attain the desired result without calling for excessive skill on the part of the smith.

Experimentation with the heat treatment of the shank and bit ends of the steel might lead to alterations in the present method of heat treatment that would do away with or mitigate the evil effects of the sharply defined zones of structurally different material, which must result to a more or less extent from present practice.—Abstract of Paper presented at the New York Meeting, February, 1921.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

THE CORROSION OF STEAM BOILERS

In the early days of steam turbine development engineers hoped that the greater part of the boiler trouble would be over. The availability of the condensed steam with its freedom from all scale forming salts or traces of oil for boiler feeding purposes opened up prospects of a new era in the boiler room. Experience, however, showed that a very soft feedwater involved troubles of its own, though just why soft feedwater attacks boilers is not quite certain. The opinion most commonly held is that with very soft water corrosion is due to oxygen or carbon dioxide dissolved in the water. If this is so, it is desirable to avoid as much as possible the exposure of the condensate to the atmosphere and especially prevent all unnecessary agitation of the water in the presence of air. This led to the advocation of closed condensate systems. Another method consisted merely in bringing the feedwater into intimate contact with an extensive surface of unprotected iron, the idea being that the water should be allowed to satisfy its craving for iron by attacking metal specially provided for the purpose.

The engineer of a large London power station some time ago tried the experiment of filling his hot well with pieces of oil boiler tubes. They were strongly attacked by the water which was found to contain far less dissolved oxygen after passing over them than did the air pump discharge. In the course of time, however, the action practically ceased on account of the protective coating of rust which was formed on the tubes.

Mr. Kestner (paper before joint meeting of the Institution of Mechanical Engineers and Society of Chemical Industry, March 4, 1921) secured continuous operation by reversing the direction of flow of feedwater. In another instance interesting results were secured by fitting some of the boilers with cast iron economizers and the rest with steel ones. With the same feedwater corrosion took place in the boilers with cast iron economizers, but not in the others, the steel economizers themselves being attacked.

This would indicate that the corrosive capacity of feedwater is limited and may be eliminated by giving the water something to attack. In this connection it is stated that corrosion troubles were practically stopped in a certain steel economizer by filling it up with a mixture of lime and carbonate soda, removing the safety valves and subjecting the mixture to a protracted boiling at atmospheric pressure.

The attacks are often of an erratic nature. Sometimes one boiler out of a group is attacked; at other times the main feed line along the boiler fronts is safe while considerable trouble is experienced with the smaller vertical connections of the boiler drums. These facts point to the probability that something in the composition of the steel may be a determining factor. Tests by H. P. Gaze of the Central Electric Supply Co. would further indicate that ordinary commercial steel tubes supplied by the economizer makers suffer less from corrosion than charcoal iron tubes, which would dispose of the contention that modern steel is a poorer metal in respect to corrosion than old-fashioned iron.

The author arrives at the conclusion, however, that there is more than a possibility that pitting is not entirely due to chemical causes but is rather of an electrolytic nature. A lack of perfect homogeneity in the steel would tend to cause electrical currents to circulate between different points, the currents passing through the body of the metal and returning through the water. Wherever such currents left the metal they would carry iron into solution and so eat away the surface. The suspension of a zinc plate in the boiler might not suppress these parasitic currents, as it could do nothing to alter the fact of a relative difference of potential between two points on the boiler shell.

The general conclusion arrived at is that until we can get metal which is chemically homogeneous or can devise some effective method of protecting the surface or possibly rendering it passive, corrosion can only be prevented by paying careful attention to the impurities in the feedwater. In modern plants these consist of little more than dissolved gases, which fortunately can be eliminated or neutralized without very great difficulty when once the danger of their presence is properly appreciated.—Editorial, *Engineering*, Vol. 111, No. 2891, May 27, 1921, pp. 651-652.

COMPARATIVE TESTS OF STEELS AT HIGH TEMPERATURE

By R. S. MacPherran

Data of tests made in the laboratory of the Allis-Chalmers Manufacturing Company to determine the comparative properties of various steels at high temperatures. The work was undertaken with the view to obtaining information as to the best material for use under operating conditions of 600 to 1,000 deg. fahr.

Measurements were made with an electrically-heated box in which the pyrometer head was practically in contact with the center of the test specimen. It was found that there is no one temperature at which all steels show a decided change in physical properties and this point varies with the composition and treatment of the steel.

The maximum tensile strength for rolled carbon steel annealed, and forged 3.25 per cent nickel steel annealed, occurs at about 600 and 650 deg. fahr.

The majority of the tensile strength curves, especially those of heat treated steels drop sharply as the temperature exceeds 800 deg. fahr. The effect of nickel in small amounts is slight, but in large percentages it tends to lower the temperature at which tensile strength begins to decline. Nickel steel is the only steel examined where the ductility materially diminishes at the higher temperatures, Monel metal bars behaving in the same manner.

Alloy steels containing chromium are less affected by rise in temperature than carbon steels and it has been generally found that apparently the introduction of metals forming carbides tend to strengthen steels at high temperatures.

This, to a certain extent, bears out the results of tests on the comparative retention of physical properties in alloy steels at 1,200 deg. fahr. or over by Leslie Aitchison, who finds the order of value to be tungsten, high chromium and 3 per cent nickel.—Paper read at the meeting of the American Society for Testing Materials, June 24, 1921. Abstracted through *Chemical and Metallurgical Engineering*, Vol. 54, No. 26, June 29, 1921, pp. 1153-1165.

CONCRETE REINFORCED WITH WOOD

Shortage and at times complete lack of steel during the war has given an impetus toward the use of concrete and, concurrently, a method for reinforcing concrete by non-metallic materials. The Italian engineer, Mario Viscardini, in the early part of 1918 produced concrete beams reinforced by wooden lattice work. Tests on these beams have shown that in general they behave practically in the same manner as similar beams reinforced with steel, but, of course, the numerical values of elastic limit and total strength are different. If wood reinforced beams are overloaded they begin to crack, the cracks being larger and more clearly defined than in the case of steel reinforced beams, but like them they can be easily repaired providing the stress does not exceed the elastic limit.

The same results have been obtained in tests made by von Emperger and an Austrian commission who have carried out

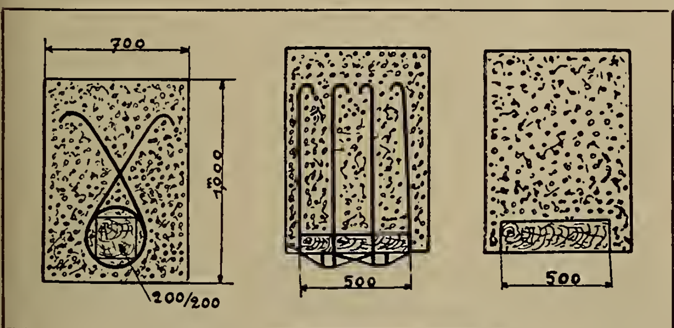


FIG. 1. DISTRIBUTION OF WOOD REINFORCING ELEMENTS IN CONCRETE BEAMS RECOMMENDED BY AUSTRIAN COMMISSION

an extensive series of tests on wood reinforced concrete beams and have found that the ratio of coefficients of elasticity of concrete and wood may be practically accepted to be unity.

One of the difficulties with wood reinforcement lay in the fact that in the first place the reinforcing elements had to be straight and in the second place it was not feasible to provide the usual abutments to increase the adherence between the concrete and reinforcing elements. Among other things it was found that tarring the wood reinforcing elements reduced the adherence, whereas a wash consisting of chalk cement, and in particular magnesia cement, over the wood reinforcing elements apparently increased the adherence. Further tests by the Austrian commission have also shown that the proportion of wood in reference to the total section of the beam should not exceed a certain percentage. In particular, beams of sections such as shown in Fig 1 proved to be best.

In Germany a beam has been developed employing both steel and wood reinforcing elements (Fig. 2). There the reinforcements which are in tension are of steel and the ones in

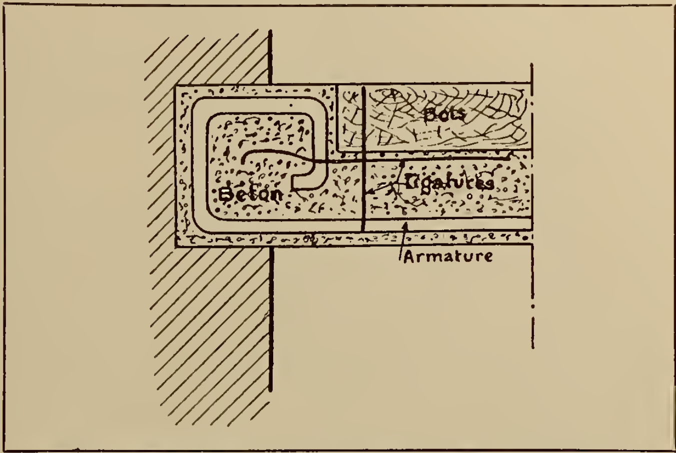


FIG. 2. GERMAN STEEL-WOOD REINFORCED CONCRETE BEAM (BETON, CONCRETE; BOIS, WOOD; ARMATURE, STEEL REINFORCEMENT; LIGATURES, TIE PIECES)

compression are of wood in addition to which the wood element happens to be placed so that it forms the top of the beam and may be used for attaching boards, etc. Theoretically such a construction is complicated but may have practical advantages.

One of the most interesting applications of wood reinforced concrete has been made in the construction of the steamer "Linnea" in Sweden. This is a 700-ton vessel built essentially with the framework of an ordinary wooden ship and concrete applied over it. The vessel has been in service on the Baltic and has apparently given satisfaction. (The original article describes an interesting method for launching it as concrete vessels can be conveniently launched with the usual gear.)—*L'Outillage*, Vol. 198, No. 10, March 10, 1921, pp. 238-284.

ALUMINUM CASTING

By John G. A. Rhodin

As regards the design of dies, the author discusses dies constructed as individual units with all clamping arrangements, etc., made and adapted for the die, and dies made in sections to suit a universal holder, like the plates in a filtering press. In England, the first method has been found to be best as it gives the designer more freedom in selecting the position of the casting of the die, combining vertical and horizontal sections, etc.

Some information is given as to the design of such dies and it is stated that the principal thing is to start working out the die from the main section and find out the smallest number of others feasible. So far such dies have been used only for making pistons of various more or less complicated design. Fans, propellers, etc., have also been made in quantity, but they belong to the class of machine parts that work without accurate fitting. Racing parts of machinery of great variety have also been cast in built-up dies and their number was increasing when the industrial stagnation came.

One of the advantages of these self-contained dies is that they can be put bodily in a furnace for heating and taken out ready for immediate pouring. With regard to limits of dimensions the writer has seen castings with rungs well over 2 feet and weighing more than 1 cwt. produced in dies of this type, such as gear cases and steering wheels for motor cars.

As regards the building up of a number of dies in the shape of plates which could be handled in a screw press, the author is less optimistic. For very simple things the plan is satisfactory, but in complicated castings it is claimed to be hopeless. The plates were supposed to slide on bars, but the bars proved to be in the way of everything when the casting had to be removed. The dowel pins holding the outside plate of the die were found to have a tendency to stick on slight provocation, and, in general, while the whole thing worked occasionally, universal application was abandoned.

Gravity method is not suitable for use on castings with very thin sections when high pressure must be used. Plunger pressure proved successful with small castings of antimonial lead but aluminum would spoil the fitting of a plunger in no time. Because of this, the majority of pressure casting machines are worked by compressed air.

The author tried a number of machines obtained from America in 1919 and says that with aluminum we had no luck. At the start really marvelous castings were produced, but in many cases the perfection was only apparent as they were full of gas bubbles under the skin.

His criticism of the design of these machines is that to begin with the permanent contact of the molten metal with iron is totally unnecessary and the same applies to the exposure of a large surface to the air. Furthermore, the gas in the castings is air which passes by hammer action through faulty design of the gooseneck.

As regards defects in aluminum castings, blowholes are mentioned. They are apparently the result of an evolution of gas dissolved in the metal and are nearly always associated with overheating of the metal. Certain impurities like manganese, and to a lesser extent, iron, enhance the effect.—Aluminum and Its Alloys in Engineering, serial article, Section 7, Chapter 5; *Engineer*, Vol. 138, No. 3416, June 17, 1921, pp. 635-636.

SOME DEVELOPMENTS IN CENTRIFUGAL FAN DESIGN

By F. W. Bailey and A. A. Criqui

The authors claim that when multi-blade forward-curved blade fans supplanted the older type of straight radial blade fans, two very good characteristics of the old blade fans were lost. One of these was the pressure curve which rose continuously with the decrease in capacity and the other was the power curve which increased constantly with increasing capacity. In the forward-curved blade fan the pressure curve drops or flattens with decreasing capacity within the working range of the fan, while the power curve has a more abrupt rise as the load increases, a combination which sometimes causes serious trouble in fan installations. The flat portion of the pressure curve makes the fan very sensitive to resistance variation and if used at a capacity corresponding to this portion of the curve may make the fan run under or over the estimated capacity. This is particularly so if the friction of the system is slightly greater or less than was estimated or if an existing duct system is changed with the consequent change in resistance.

With the directly connected unit when a fan which has an abruptly rising power curve runs above the estimated capacity there is a decided danger of overloading the motor. With the motor-driven forward-curved blade fan run at this critical point in its range, it is necessary to supply an excess of motor power with a probability of running the motor at reduced capacity and therefore reduce the efficiency to guard against the possibility of the fan overloading. This represents a perpetual insurance payment when using a forward-curved blade fan under these conditions. The flat or drooping portion of the pressure curve also causes trouble in double-width fans or when two single fans blow into the same duct system, provided that the capacity comes within the range of this flat portion of the curve. If there is some difference in the resistance at the two inlets, which frequently happens, the capacity of one wheel will be reduced without any corresponding increase in pressure and this wheel then has no power within itself to regain the load, with the result that sometimes air will go in only one inlet of a double-width fan and the other wheel will merely churn the air in and out of its inlet.

A desirable combination of fan characteristics would be to retain the good features of the old radial blade fan and at the same time have the high capacity range insuring a small housing together with the higher efficiency of the forward-curved blade fan. During the past few years a new type of multiblade fan has been developed which is said to combine these good features. This fan has blades which curve forward at the heel to meet the incoming air, but curve backward at the tip to discharge the air. Thus, while the blade of the forward-curved fan is a portion of the surface of one cylinder or one cone the blade of the new backward-curved blade is formed from the surfaces of two cylinders or two cones as shown in Fig. 3.

Fig. 4 shows the comparative pressure curves of a forward- and double-curved blade fan. The latter has the continuous rising pressure curve, which, when capacity decreases, builds up a pressure to overcome the added resistance. In double-width fans when one inlet is more restricted than the other, the tendency is for less air to flow through that inlet. In such a case the restricted wheel will build up a pressure to meet the added resistance and will thus retain its share of the load. As a result, a double-width fan of the double-curved blade

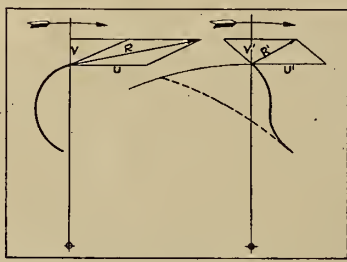


FIG. 3. COMPARISON OF THE FORWARD- AND BACKWARD-CURVED DESIGNS OF BLADES FOR CENTRIFUGAL FANS

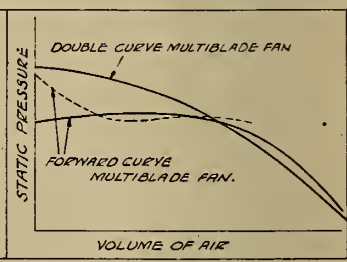


FIG. 4. COMPARISON OF PRESSURE-CURVES OF THE FORWARD- AND DOUBLE-CURVED BLADE TYPES OF FANS

type will divide the load between the two wheels throughout the whole range of capacities and neither of the parts will simply churn the air as in the forward-curved blade type.

The original article gives also curves showing the comparative static efficiencies of forward and double-curve blade fans and a comparison of their power curves.

The two types are not always competing. The forward-curved multi-blade fan is preferred where very high outlet velocity is required and noise is not objectionable. On the other hand, the double-curved multi-blade fan is essentially the medium capacity fan and lends itself particularly to that class of ventilating work where very high outlet velocities are not needed or desirable; at the same time it is decidedly a higher capacity fan than was the old radial blade fan.

Double-curved multi-blade fans are inherently higher speed fans than are those with forward-curved blades and this brings up the question of specifications. With the advent of the forward-curved blade trouble was experienced from noisy fans which was attributed to the higher speeds at which these fans ran. Engineers and architects, therefore, got the habit of writing into their specifications clauses which limited the speeds of multi-blade fans in order to insure large sizes or relatively slow-speed makes. As a matter of fact, the noise had very little to do with the speed of the fan. Double-curved blade fans do not cause as much noise and at the same time must be run at high speeds. Therefore specifications which fix low speeds would practically prohibit the use of double-curved blade fans.—*Journal of the American Society of Heating and Ventilating Engineers*, Vol. 27, No. 4, May, 1921, pp. 375-380.

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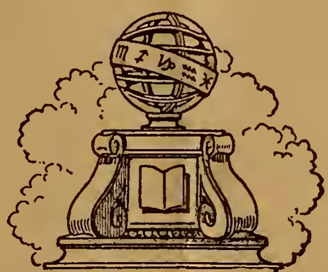
SCIENTIFIC AMERICAN MONTHLY



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A TYPICAL EXAMPLE OF THE OPEN-CUT METHOD OF MINING ASBESTOS IN QUEBEC
Note the human figures in the left foreground, giving an idea of the size of these stripping operations. (See page 245)

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FAMILIARITY BREEDS CONTEMPT

When we were young and still in possession of many of the illusions of youth, we recall that one of the things about which these illusions were particularly strong was the Constitution—Federal or State, as the case might be. When we read in the morning paper that this or that enactment had been adjudged by the court of last resort to be unconstitutional, we had a very definite picture of the deep humiliation of the legislature that had passed the offending statute. It must be weeks, we supposed, before the cloud would be entirely dispelled; and we wondered whether the individual drafter of the objectionable act would ever be the same again.

The manner in which we lost this particular illusion is part of the story. We were employed for a few months as office boys in a larg law firm, one member of which specialized heavily in arguing appeals. In the library one fine morning we overheard him in consultation with another of the partners, one of whose cases was having a rough time of it in the lower court. They agreed that there was little hope of an immediately favorable decision, since the law seemed pretty definitely against their client. Then, while we wondered when and how they would break the news to this unfortunate creature, the junior member remarked, "Well, that leaves just one way out when the case comes into your hands." "Yes," the senior responded nonchalantly: "we shall have to attack the constitutionality of the law." Just like that: as casual as asking the umpire to throw out a damaged ball.

This little tale, it seems to us, has direct bearing upon the attitude of the insider and that of the outsider in any field of endeavor. The proverb which we have set down at the head of this column runs through all human affairs. The physicist may look with a good deal of respect upon what he supposes to be the mathematician's sacred structure of Euclidean geometry; but his own fundamentals he revises again and again with ruthless hand, to make them better suit the passing needs of the moment. He overthrows the entire structure of physics and philosophy in order to replace this edifice with a new one in better harmony with what the outsider would be inclined to regard as a few rather insignificant experiments, whose explanation might well be left open.

In the same way and with few exceptions indeed, every science is today in an extremely open-minded attitude toward its own fundamentals—more ready to revise them than the watching world is to have them revised. And to be sure, is not this well? The old proverb has a ring of reproach; but it was writ when illusions bulged large in the mental equipment of the human race. Better that familiarity should make us contemptuous of our accepted scientific doctrine than that too great respect should breed in us the dogma which has so impeded progress in the past.

"ENGLISH AS SHE IS SPOKE"

There is noticeable today a growing tendency to assume that the language is ours, to do with what we will. It is of course true that in many respects consensus of usage makes good usage. Words come to mean things far from their original significance, simply because we insist upon using them in such meanings. Pronunciations as regards both single words and general principles, change widely with the passage of years. Even farther than this it is proper to go; anything that savors in the least degree of convention we should be free to alter if we wish.

For instance: there really is no very good reason why we should insist upon using the predicate nominative. It is entirely reasonable to say that the substantive in the predicate ought to agree with the subject; it is equally reasonable to insist that all verbs, transitive or otherwise, ought logically to be followed by the same form. No less an authority than Professor Lounsbury of Yale looked forward to a time when we should all say "It is him."

Again, just as English and French differ in this point, so do they differ in many others. The Frenchman says "without to go," "for to act," where we say "without going" and "for acting." The choice between infinitive and participle (or gerund, if you insist on calling it that) is purely a matter of convention, and is subject to change. The German, if we translate him literally, writes a book "over" the thing he has on his mind instead of "about" it; and his use of "an" and "bei" is absurdly at variance with our handling of their cognates. He uses "through" to indicate the agent with the passive verb where we employ "by." All these usages, and in fact the choice of almost every preposition, are matters of pure convention and entirely subject to variation at our pleasure. Even the manufacture of a new word through the juxtaposition of "on" and "to" we can effect if enough of us insist upon it.

All this and much more is proper; the minute we get a majority on the side of change, the new expression becomes automatically correct. But there are some things that no majority can ever do to our language. The New York *Tribune* and some unidentified member of the English faculty of Columbia University to the contrary notwithstanding, "else" is an adverb and not a pronoun. It takes more than mere consensus of usage to make a pronoun of it, and to bestow a possessive case upon it, so that we could say "some one else's" without laying ourselves open to the retort "which Elsie?" Some millions of Southerners to the contrary notwithstanding, "like" is a preposition and not a conjunction; we can do things *as* some one else *does* them, or we can *act like* this some one else, but we can never do things *like* he *does* them without murdering the English language. Similarly in the case of "without" vs. "unless." And these are but a few examples out of many.

The Size of the Galaxy*—I

New Results from a Study of Star Clusters and the Structure of the Universe

By Harlow Shapely, Ph.D., Mount Wilson Observatory

From time to time, in his monthly contributions to the Scientific American *(the regular weekly edition), Dr. Russell, himself one of the world's leading astronomers, has told our readers something of Dr. Shapely's monumental work in the examination of the size and structure of the universe of stars. Dr. Shapely of course has himself put his findings into print, but not, we believe, before a general audience. It accordingly affords us gratification to give him space for a discussion of what he regards as the outstanding features of his investigations of so many years.*—The Editor.

The modern investigation of the origin and structure of the sidereal universe is a problem for the ordinary branches of physics rather than, as in times past, a subject wholly within the realm of metaphysics and theology. The application of the principles and methods of the physical sciences to the study of sidereal conditions—the science of Astrophysics—is at the basis of our researches into the arrangement of the stellar system, its past and its future history. We measure light, mass, time, and length, the most important for our present problem being length—that is, the distances and dimensions of the various celestial objects.

Our conceptions of the dimensions and structure of the galactic system necessarily change with time. The evolution of cosmic interpretations must keep pace with the growth of the great observatories, with new developments in physics and astronomy. Until recently we have been content to believe our disk-shaped Galaxy but a few thousand light-years in greatest diameter (a light-year is the distance light travels in a year—about six million million miles); various studies of stellar clusters and of faint variable stars, however, indicate that the system is several thousand times more voluminous than previously thought. An account is presented in the following pages of some methods and results of my work on variables and clusters in so far as they bear on the size of the Galaxy.

Since with advancing knowledge of the stars the distances increase in the known sidereal universe, the futility of our ordinary procedure in fathoming the depths of space grows more apparent. A thousand stars are within the reach of the usual triangulation methods; thousands of millions are hopelessly remote.

The need of more powerful and expeditious ways of measuring sidereal distance has led astronomers to various devices. The usual trigonometric (triangulation) method consists in observing the position of a star in the sky at different times of the year, commonly when the earth, as seen from the star, has maximum angular distance from the sun. Greater numbers of stars may be reached through using as a base line for triangulation not the diameter of the earth's orbit as in the method mentioned, but the ever-accumulating distance, due to the motion of the whole solar system through space. Statistical analysis of stellar motions across the surface of the sky and in the line of sight have given us average distances of large groups of brighter stars. A spectroscope method devised by Adams and Kohlschütter permits the determination of the distance of most types of stars for which spectra of sufficient dispersion can be obtained.

I. The Rôle of Variable Stars in the Measurement of Great Stellar Distances

The study of two kinds of variable stars, however, yields results that allow us to reach farther into space than has heretofore been within our power. The distances of certain objects, so remote that they are scarcely visible with the greatest telescopes, can now be deduced with accuracy, and considerable steps can be made toward a better appreciation of the extent of the sidereal universe. The following paragraphs are devoted to a discussion of the methods of measurement that are based upon studies of the brightness of variable stars.

The principles involved in the determination of stellar distance through measures of the quantity of light are very simple. As an illustration let us consider a series of street lamps observed visually (or photographically) from a fixed station. Suppose the lamps are all of the same candle power. To the observer, the near ones will appear bright, the distant ones faint, the brightness decreasing as the square of the distance increases. If one of these equally luminous lamps is ten times as far away as the nearest, the observer receives from it but a hundredth as much light; and it is fainter by five magnitudes, if we express the relative amount of light in the ordinary astronomical units. When the observer measures the quantity of light received from each lamp, he can compute immediately their relative distances; and then, if he determines by triangulation or some other direct method the actual distance to the nearest lamp, he may compute at once the actual distances of all the others.

The problem of distance is the same for street lamps and variable stars. We find from studies of motion, light variation, color, and spectrum how to estimate the actual candle power of the different stars. Then through ordinary methods of astronomical photometry we measure the quantity of light received from a star—its apparent brightness—and easily derive the distance. In other words, this comparison of their actual (absolute) brightness with the brightness they appear to have is a key to the distances of stars. By definition, the absolute and apparent magnitudes are the same at a distance of 32.6 light-years. A simple formula states the numerical relation between length and light. If M is the absolute magnitude and m is the apparent magnitude, then the distance, d, expressed in light-years, is given by

$$\log d = 1.514 - 0.2\ (M - m).$$

The most distant objects, which are of highest importance for studies of the structure and extent of the universe, are of course extremely faint. In fact, some of the stars that are involved in my investigations of clusters are more than 100,000 times fainter in apparent brightness than the faintest stars visible with the unaided eye.

Stars vary in light, position, velocity, color, and other properties; ordinarily, however, when we speak of variable stars we mean only those that vary in brightness. An important and numerous variety of variable stars is the eclipsing binary—a double star whose components move in an orbit inclined at such an angle that, to the observer on the earth, the light is periodically and temporarily diminished through eclipses. Algol, the second brightest star in the northern constellation Perseus, is the best known member of the class. The systematic study of the brightness of such a double star permits the astronomer to derive a light-curve, that is, a plot of magnitude against time, showing the variation of the light throughout the course of a complete revolution in the orbit.

*Adapted by the author from a series of articles published in *Scientia,* October, November, 1919, February, March, 1920.

In the most favorable cases as many as a dozen independent properties of the eclipsing binary and its orbit may be obtained from a mathematical study of the light-curve. A similar number of interesting dependent quantities may be derived, among them the absolute brightness of the component stars—the quantity that is important for our studies of the structure of the universe—for, as stated above, when we know the actual brightness, the easily determined apparent brightness immediately gives us the distance.

The absolute magnitudes and distances of nearly a hundred eclipsing stars have now been computed as by-products of the study of the stellar orbits, and it is found that a distinct advance has been made over direct measures of distance. Of the ninety variables whose parallaxes have been derived and discussed by Russell and Shapely, two-thirds are more distant than a thousand light-years, quite beyond the sphere of accurate measurement by trigonometric methods, and a number of them are more than five thousand light-years away.

The inferiority of our sun as a light source, when compared with many of the naked-eye stars, is frequently noted by astronomers. As a class, eclipsing binaries also are intrinsically very bright relative to the sun. Although some exceed its candle power but little, most of them are from ten to a hundred times as luminous, and many emit a thousand times the equivalent of the solar radiation. In fact, the so-called dark companions in eclipsing systems usually far exceed our sun in size and in total radiance.

Similarly, the Cepheid variables (these receive their name from Delta Cephei, the first known variable star of the kind) are giants in absolute brightness. They are always, in fact, more luminous than a hundred suns, and those which are equivalent to a thousand suns are typical members of the class. Much attention has been given this type of variable in recent years. They are known to vary periodically and synchronously in color, spectrum, and apparent velocity, as well as in stellar magnitude. They seem to be single stars, rather than binaries, and their variations are interpretable as periodic pulsations in gigantic volumes of luminous gas. The period of pulsation is in some cases but a few hours, in others, several days or weeks; but for any given star the period is usually constant within a small fraction of a second. A quick rise to maximum light, followed by a slower decline to minimum, characterizes the typical Cepheid light-curve.

Because of their very high importance in problems of sidereal distance, and their peculiar bearing on questions of the dynamics of stellar evolution, no class of stars is of greater significance in modern stellar astronomy than the Cepheid variables. The determination of their absolute magnitudes and distances is a much more direct and accurate process than for eclipsing binaries. In place of the complicated relations between spectrum, period, dimensions of the stars, and relative luminosities, which enter the orbital theory for eclipsing stars, we need only the period of light variation to get the absolute magnitudes of Cepheids.

Some years ago Miss Leavitt at the Harvard College Observatory pointed out that for 25 Cepheid variable stars of the small Magellanic Cloud the length of the period of variation depends upon the *apparent* brightness. The periods range from two days to more than three months. Since the variables in the Cloud are all at essentially the same distance from the earth, the correlation is actually between *absolute* brightness and period of variation.

The work on clusters and variable stars during the last few years at Mount Wilson permits the development of this correlation into an instrument of much usefulness. The period-luminosity relation has been accurately defined throughout the whole interval of brightness, spectrum, and period in which Cepheids occur. Variables from many globular clusters and from the scattered stars of the Milky Way have been analyzed as to light-curves and periods. The motions and measured distances of the relatively near stars of this class have been utilized to establish for all Cepheids the scale of distance in terms of known units. The result is a definitive curve, connecting absolute magnitude with the logarithm of the period; it shows that the more luminous the variable, the longer its period, and that the least luminous have periods shorter than a day.

As soon as variable star observers have derived the period and apparent magnitude of a Cepheid, the absolute magnitude may be read from the period-luminosity curve and the distance computed with the aid of the formula given above. Thus the remarkable physical properties of a luminous gas, which closely unite the actual brightness of giant stars with the period of pulsation and variation, give the position in space of all known Cepheids. Though actually very bright, many appear extremely faint because of distance. Cepheid variables, therefore, as well as eclipsing stars, permit us to go out much farther into space than we had hitherto gone.

It is not, however, in exploring the immediate vicinity of the sun that these variable stars contribute so much to knowledge of the structure of the universe. It is rather through their frequent occurrence in other remote stellar organizations, such as globular clusters, that they aid greatly in surveying the sidereal system; for it is clear that, in giving us their own distances, the variables in clusters are at the same time revealing the distances of the vast assemblages of which they are members. In this manner they show us the distribution of objects so remote that, to reach our earth, their light must

PLASTER MODEL OF THE TOP OF MOUNT WILSON, SHOWING THE OBSERVATORY

The 100-inch and 60-inch reflectors are located within the two largest domes. The tower telescopes are used in solar investigations. Model and photograph by F. Ellerman

travel many thousands of years across the intervening emptiness of sidereal space.

II. GLOBULAR CLUSTERS AS COSMIC UNITS

Among the stars social relationships are nearly as common as among men and the lower animals. Sidereal bodies that are completely independent of all star societies are difficult of conception; for the immediate environment, as well as the heritage of early and ancestral association, influences the present behavior and the destiny of stars. Planetary systems, binaries, groups of three or four nearly equal bodies, are thought to be very common—almost universal, it may be; and the assemblage of stars of all kinds by the tens, hundreds, and thousands into physically organized clusters now appears to be a property of fundamental significance in stellar investigations.

In considering the aspect of clustering among the fixed stars we see a gradual progression from the largest and most scattered constellations to such rich and highly concentrated stellar groups as the globular clusters. Although the constellations were outlined for the most part in prehistoric times and have been used in myths and astrology for thousands of years, they do not in general represent definite physical organizations that exclude the stars of neighboring groups; and frequently even the legendary relationships of the stars in the most anciently known constellations are traced with difficulty.

There is, however, among the varied groupings, an easy transition from widely-scattered Ophiuchus and Camelopardalis to Orion, Scorpio, and the Great Bear; and in recent years we have found that the most conspicuous stars of these three last-named constellations actually form physical stellar systems. The stars of each have motions, colors, and distances in common, and in each case they have evolved, no doubt, from an origin common in space and in time. From Orion we readily trace the progression in clustering to the Hyades—a more compact and more definitely circumscribed dynamical system—and then to the Pleiades, to Praesepe, to the double cluster in Perseus, and to similar faint loose clusters of the Milky Way; thence, by way of Messier 11 and Messier 22, we proceed by nearly equal steps to typical globular systems exemplified in the great Hercules cluster, Messier 13.

Although we may justly restrict the term star cluster to physical systems—that is, to groups which have the characteristics of distinct dynamical organization—it is clear that the subdivisions of the long sequence from Orion to the Hercules cluster must necessarily be vaguely defined. For convenience we here distinguish only open and globular clusters, and designate all as open except those eighty or ninety highly condensed groups whose stars appear innumerable even with the aid of our largest telescopes and most sensitive photographic plates.

Open and globular clusters, however, differ in matters other than richness and apparent circularity. In average distance from the earth the globular clusters much excel, in stellar constituency they are more varied, and we recognize that, from a dynamical point of view, in their wide spatial distribution the globular clusters are quite distinct from the open groups which closely congregate along the middle line of the Milky Way.

In the second paper of this series it will be shown that most of the globular clusters are isolated systems, neither intermingled with nor closely surrounded by other stars. They may be treated, therefore, as distinct cosmic units. Their ultimate destiny, to be sure, may be disintegration and dispersion throughout wide regions of sidereal space. Their careers as distinct self-governing units may end, as the later discussion will show, by the absorption of all of them into a sidereal federation that is greater, more powerful, and more permanent; yet the form, content, and other characteristics of globular clusters at the present time constitute a fairly legible record of conditions that have existed for many millions of years—a record, moreover, of a stage that appears to be representative and fundamental in the slow evolution of sidereal organization.

In treating globular clusters as individual units, we may fulfil the purpose of the present article by discussing briefly a single system. In certain details, there are, to be sure, conspicuous differences from cluster to cluster; but in such matters as size, number of stars, and stellar make-up no great diversity appears.

The Great Cluster in Hercules (No. 13 in Messier's well-known compilation) is the system chosen for the present illustration. The right ascension of the cluster is 16h. 38m. 1, the declination is +36° 39′ and it is faintly visible, as a hazy star of magnitude 5.8, about two degrees south of Eta Herculis.

At the commencement of my studies on star clusters (*Mount Wilson Contributions*, Nos. 115-117, 126, 129, 133, 151-157, 160, 161, 175, 176, 190, 1915-1920; *Mount Wilson Communications*, Nos. 18, 19, 34, 37, 39, 44, 45, 47, 54, 62, 63, 64, 69, 1915-1920; and various papers in the *Publications of the Astronomical Society of the Pacific*, 1915-1920), Messier 13 was placed first on the list for detailed photometric examination because of its favorable position in the northern sky and because earlier work on the positions and spectra of its stars facilitated the interpretation of observational results. The large reflectors at Mount Wilson are well adapted to the study of rich clusters of this kind. A photograph of Messier 13 on a rapid plate with the 100-inch reflector shows the images of more than a thousand stars in less than a one-minute exposure. The photograph reproduced on facing page was made with the 60-inch reflector by Professor Ritchey, on a plate of medium rapidity, with an exposure of eleven hours; it records something like 30,000 stellar images brighter than the twenty-first magnitude. Nearly all of these are actual members of the cluster and not merely objects of the foreground, projected among the cluster stars.

The detailed photometric work on the stars in Messier 13, supplemented by the study of the distances of all globular clusters—a study which has involved investigations of Cepheid variables, red giant stars, stars of spectral type B, and the apparent diameters of clusters—lead to a definite determination of the position in space of the Hercules cluster. The parallax now adopted is 0″.00009, a value corresponding to a distance of a little more than 36,000 light-years.

Even to those who are accustomed to think of the great depths of sidereal space, it is difficult to comprehend clearly the remoteness of the Hercules cluster, notwithstanding that it is one of the very nearest of all the globular clusters whose radiation is continually streaming toward the earth. Its distance, 3.5 times 10^{17} kilometers, is more than eight thousand times that of the nearest star now known. Light, traveling with the hardly conceivable velocity of 300,000 kilometers in a second of time, requires eight minutes for the passage from the sun to the earth; but it must travel more than two thousand million times as long to reach us from this globular cluster. Hence our knowledge of the position and physical characteristics of Messier 13 does not refer to the system as it now exists. Our most recent information dates from the time the light we now receive left its remote origin in the cluster; and what has occurred there during the last 360 centuries is beyond our power of finding out. On the basis of our knowledge of the probable causes of these past conditions, we may believe with good reason that the cluster is at the present time much as it was 36,000 years ago. Such an interval of time is of small consequence in the life history of a gigantic stellar system; but while these pulses of light have been coming across the intervening fraction of unending space a thousand human generations have come and gone; man has emerged from a vague, unrecorded past and in fleeting succession all his historically known national civilizations have slowly evolved, flourished in vaunted permanence and supremacy, and quickly relapsed into oblivion or poor mediocrity.

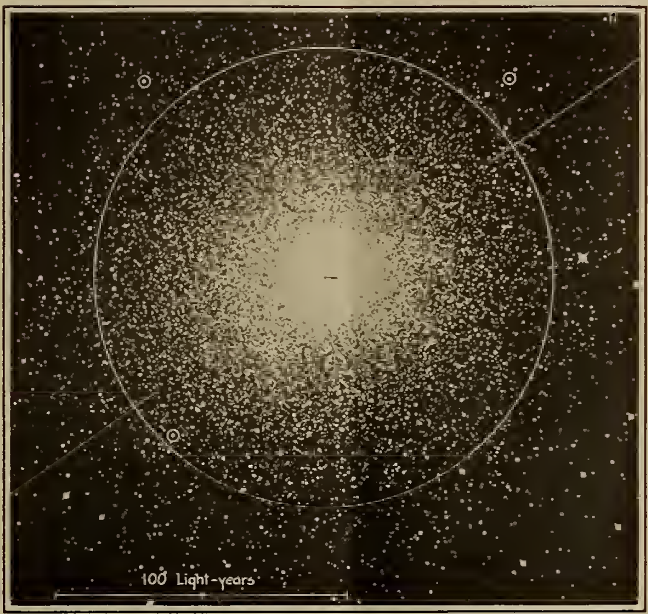
With the distance of the cluster known, we readily translate angular dimensions, as measured on the surface of the sky, into

linear dimensions. Thus, by the definition of parallax, the angular length 0".00009 corresponds in the Hercules cluster to the linear length of one astronomical unit—the distance separating sun and earth. By transferring a linear scale to the cluster, therefore, as in the accompanying illustration (which does not include the outlying stars), we may determine the separation of the individual stars, the number in a given volume, and numerous other facts concerning the physical structure of the system. It is worthy of emphasis that in determining the distance of the Hercules cluster we have at the same time derived the distances of its tens of thousands of stars.

A conception of the great size of a globular cluster may be gained by indicating on the picture of Messier 13 some of the familiar distances of the solar neighborhood. The distance separating the nearest known star from the sun (4 1/3 light-years for Alpha Centauri) is indicated by the short black line near the center. The distance from the sun to the Hyades, the well-known group of bright stars in Taurus, is represented on the photograph by the distance from the center of the cluster to the star marked H. The diameter of the large circle corresponds to ten million astronomical units; a sphere of that diameter, with the sun at the center, would include all the stars within eighty light-years of the sun.

The total angular diameter of the cluster is about thirty-five minutes of arc, corresponding to twenty-three million times the distance from earth to sun, or more than three hundred and fifty light-years.

All the cluster stars shown on the photograph are giants in actual luminosity, the most brilliant exceeding a thousand suns in light power. In apparent brightness, however, because of their great distance, few of them exceed the thirteenth magnitude. At the cluster's distance of 36,000 light-years, a star as bright as our sun would be considerably fainter than the twentieth magnitude—too faint to appear on this reproduction. The three cluster stars whose images are enclosed in small circles are photographically almost exactly one hundred times as bright as the sun.



ONE OF THE MEANS WHICH THE SKY HAS AFFORDED DR. SHAPELY FOR PURSUING THE PROBLEM OF THE SIZE AND STRUCTURE OF THE UNIVERSE

The globular cluster Messier 13, in Hercules. Its distance exceeds 200,000,000,000,000,000 miles and we see it by light that has been en route 360 centuries. It contains more than 36,000 stars that are brighter than our sun

Until recently the globular clusters have been accepted as spherical in shape. A systematic study of the photographs at Mount Wilson has shown, however, that a majority of globular clusters, as seen in the sky, are slightly but symmetrically elongated. This condition has been interpreted as a flattening of the cluster system—an indication that the clusters are not spheres but rather are oblate spheroids. Messier 13 is one of the most flattened; and though the elongation, in the direction indicated in the picture by inclined white lines, can be uncertainly seen visually or on photographs of the cluster, it is very readily shown by counts of the individual stars. There are about thirty per cent more stars in the direction of elongation than at right angles thereto.

The flattening suggests that this great stellar system may be in rotation about its shorter axis. Observations have not as yet determined whether or not such a motion exists. It is known, however, that the cluster as a whole is moving with a high velocity; and since the mass is probably in excess of 100,000 suns, we appreciate that the momentum of this moving cosmic unit must be exceedingly great. The only component of the motion now known, nearly two hundred miles a second, is directed toward the earth and toward the great extended strata of stars that constitute the galactic system. If the cluster continues to move with this velocity, it will have reached the galactic plane within fifty million years, coming from its present isolation in space to the regions where scattered galactic stars are numerous and where all the open clusters are found.

(To be continued)

DIFFERENTIATING THERAPEUTIC RAYS IN SUNLIGHT CURES

The famous physician who has done so much to spread the doctrine of the therapeutic value of sunlight, Dr. E. Roux, recently made a valuable communication to the French Academy of Sciences, concerning the difference in effect of light rays and heat rays. His remarks which were presented at the Session of April 18, 1921, read as follows:

The exceptionally favorable conditions for the practice of helio-therapy which are presented by the atmosphere in the vicinity of Mt. Blanc and especially at St. Gervais, have enabled me to collect numerous series of data concerning the treatment by this natural curative agent of ordinary a-tonic wounds including varicose ulcers, burns, surgical wounds, etc.; as well as bacillary fisculas, tuberculosis of the ganglions, lupus, chronic arthritis of tuberculous or rheumatic nature, sciatic neuralgia, and other forms of neuralgia. Still another group of invalids treated by means of helio-therapy includes a certain number of persons suffering from chronic tuberculosis of the lungs.

While the admirable results obtained by helio-therapy are comparatively well known, it is less widely understood that the action of the solar radiations differs greatly according to whether they are hot or cold.

In the winter during the first hours of the day the solar radiations are cold and exclusively luminous. Between 12 M. and 2 P. M. these rays are accompanied by calorific rays. Thus an invalid exposed to the sunlight between 9 A. M. and 11 A. M. is acted upon almost entirely by light rays, while one exposed between noon and 2 P. M. is subjected to the action of both light and heat.

I was able to observe with great precision that invalids having closed tuberculous lesions (adenoids, adenites, arthrites and especially local lesions of the lungs) support the cold helio-therapy of the morning hours very well, but are incommoded by the warm helio-therapy of the afternoon, which occasions congestive coughs, a rise in temperature, perspiration, which is painful even when not actually dangerous because of the rapid evaporation. Rheumatic patients, on the contrary, as well as those suffering from arthritis, neuralgia, myalgia, suffer from the cold sunlight and derive the maximum of good effect from the combined action of heat and light.

It would seem, therefore, that the physician should make a definite distinction between the therapeutic value of light and that of heat, both as regards the choice of the locality selected for any given patient and of the best season for the treatment.

TWO PHASES OF THE MISSISSIPPI RIVER DREDGING INDUSTRY

Left: Dredging for shells on a tributary of the Mississippi. *Right*: Mechanical dredge of the type that is prohibited in some states. Where tolerated, these big fellows relieve the river bottom of anywhere from three to ten tons of shells in the course of a day

America's Fresh-Water Pearl-Button Industry

An Out-of-the-Way Commercial Activity and How It Is Carried On

By S. G. Roberts

BUTTONING up America is something more than a practical necessity. Modern taste insists that this act should be performed with results for the most part pleasing to the eye.

There was a time when our citizenry of a less exacting period were generally satisfied with the modest china and humble bone button for many purposes; but nowadays the demand is for fasteners that shall be ornamental as well as useful—hence the ever-widening market for the lustrous pearl button.

Three decades back substantially all of the pearl buttons attached to American-made garments came from Germany and Austria, where their manufacture originated; but in the latter "eighties" chance led to the establishment of the business in the United States. At present our pearl-button factories, when operating to capacity, give employment to approximately 30,000 persons—many of whom are highly skilled craftsmen. It is rather suggestive that the domestic output of pearl buttons has reached a stage where we can ship them abroad, and during the year gone our exports of these articles had a total value of $712,714. They were sent to all parts of the globe, and we are, therefore, helping with pearl buttons to button up the whole world.

SHELL FISHERMAN, WITH TWO OF HIS DRAGS, AND THEIR STRINGS OF ATTACHED CROW-FEET SUPPORTED AT EACH SIDE OF THE BOAT

It is worth while recounting how we came to engage in the production of pearl buttons from native resources. Along about 1880 John F. Boepple landed on our shores and went to live in Muscatine, Iowa. Before leaving Europe he had learned the trade of making buttons from sea shells. Being fond of fishing he spent his leisure hours on the banks of the nearby Mississippi, and there happened upon some shells which he realized at once might be used for the manufacture of pearl buttons. He grasped, too, when he discovered mussel and clam shells in plenty that the regional fresh waters could be drawn upon for the nacreous materials essential to the craft in which he had qualified in the country of his birth. He visualized how an aquatic waste could be utilized in creating an industry of great promise.

His next problem was to develop tools capable of cutting button blanks from the shells and then finishing these off into acceptable merchandise. Step by step he mastered the many difficulties, and his first button-making machine was a comparatively crude foot-driven lathe. However, with this modest equipment he fashioned acceptable pearl buttons, and was able to sell them as rapidly as he could turn them out. This recognition eventually won for him the needful support of capital; and from that rather unpromising beginning have evolved the twenty-odd plants now devoted to the manufacture of fresh-water pearl buttons in the United States.

The factories are located in the States of New York, Iowa, New Jersey, Wisconsin, Minnesota, Indiana, Michigan, Illinois, Kansas, Arkansas, Ohio, West Virginia, Tennessee, Kentucky, Missouri, Oklahoma and Massachusetts. These establishments, exclusive of stocks of raw material and finished product on hand, represent a total investment of fully $4,000,000. According to the most recent figures available, the factories made 21,000,000 gross of buttons in 1914, and these were valued at nearly $4,900,000.

Since the inception of the native fresh-water pearl-button industry, machinery has been designed and built which is typically American in its capacity to do quickly and well the divers operations required in dealing with the shells and in transforming the blanks into beautifully finished buttons. But don't let us go too fast; in order that we may follow the evolution of the button we should start with the fishing for the bivalves which furnish the basic substance. These are mussels or clams of various sorts which abound notably in the Mississippi River and its numerous tributaries. Not all of them are fit for button-making, and the highest-priced commodities are manufactured from mussels commonly known as "mucket" and "niggerhead." The latter is especially valuable because it yields what the trade terms "iridescents."

The clammers or fishermen gather the mussels in two ways: by dredge, which is permitted only in some states, and by a drag consisting of an iron bar or pipe a number of feet long to which are attached by short lines numerous metal hooks. These hooks are four-pronged affairs of twisted wire and are popularly named "crow feet." The clammer drops his bar on to the water bed and draws it along over the area where the mussels are to be had. The movement is a slow one, and the bivalves, mistaking the hooks for morsels of food, close their shells upon them. They are slow to realize the nature of a crow foot, and the clam continues to cling for some time to it. Now and then, the fisherman raises his drag to the surface and collects the attached mussels, and this goes on until he has a boat load.

Harvesting clams or mussels for button making is just one phase of the fisherman's quest. Primarily, he is on the hunt for fresh-water pearls that are found of high quality in the bivalves which are plentiful throughout the drainage area of the Mississippi. Indeed, it is authoritatively stated that the incomes of the shell fishermen are derived from pearls and shells in the approximate ratio of one-third from the pearls and two-thirds from the shells. In a normal year the aggregate return amounts to something more than a million dollars. By reason of the double source of revenue, the clammer's first work after his bivalves are landed is to prepare them so that he can uncover any hidden gems.

THE MECHANICAL CLASSIFICATION BY SIZE OF THE RAW SHELLS

A STACK OF RAW SHELLS READY FOR THE BUTTON FACTORY

For this purpose the mussels are steamed in a wooden vat built as a rule of two-inch planking a foot wide. These vats range from six to eight feet in length and in width from three to four feet, and have their bottoms protected by a sheathing of galvanized iron, the metal extending half way up the sides and one of the ends. The front of this structure slopes outward from the bottom to the top, and thus forms a ramp that facilitates raking out the mussels when they have been cooked long enough. It is customary to suspend a vat upon iron rods spanning a trench about two feet deep, three feet wide, and of the same length as the tank. Rising from the rear end of this excavation is a smoke pipe, and dirt is banked around this and the two sides. This leaves an opening at the front end where the fire under the tank can be tended. This makeshift cauldron is partly filled with water and then the bivalves are dumped in. As soon as the water has reached the boiling point the mussels open up, are taken out of the vat, and the gaping shells and the cooked meat are carefully examined for pearls. Both valuable pearls and baroques are frequently concealed in the bodies of the bivalves, and these may bring anywhere from 50 cents an ounce to as many dollars a grain. The discarded clam meat is often sold to neighboring farmers for hog feed. The shells have realized from $9.50 to as much as $55 per ton, depending, of course, upon the color, the luster, the size and the thickness of the raw material.

Inasmuch as a mussel bed may harbor bivalves of several varieties the shells from a catch are, therefore, of a correspondingly mixed character, and because of this the button maker, who buys his stock in miscellaneous lots, has to assort and to classify the shells after they reach his factory. From the various shells at his disposal he produces different sorts of buttons. To classify the shells he runs them through a machine which consists principally of two oppositely revolving rolls set slightly out of parallel. This leaves a tapering gap between them. As the shells feed downward along the inclined cylinders they drop through when the space permits, and, agreeably to their respective sizes, fall into the several receptacles arranged beneath. The shells so assorted are next put in soaking tanks where they remain for a week or more. The water renders them less brittle and makes their substance tougher in order that the shells can be cut into button "blanks" or discs without splintering.

The operatives that cut the blanks are specialists, each of whom has become skilled in handling a particular kind of shell and in getting the greatest number of blanks from every

AFTER THE BUTTONS ARE CUT, THEY ARE GROUND DOWN TO SIZE ON THIS MACHINE

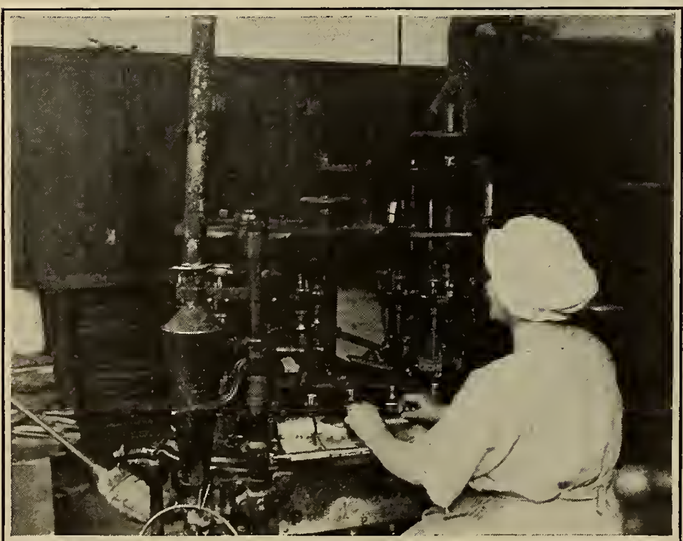
A POLISHING AND GRINDING MACHINE THAT TURNS OUT 2000 GROSS OF BUTTONS A WEEK

half of the bivalve's erstwhile cloak. The blanks are formed by tubular saws which are carried in a chuck of a lathe-like machine. One by one the blanks are shoved onward through the hollow of the saw and drop from the chuck into a bucket. All the while the saw is eating out discs from the shell the tool is sprayed with water to keep it cool and to drown any dust. The latter precaution is for the purpose of safeguarding the health of the workman. Otherwise the minute and sharp-edged particles might injure the eyes and seriously irritate the artisan's lungs.

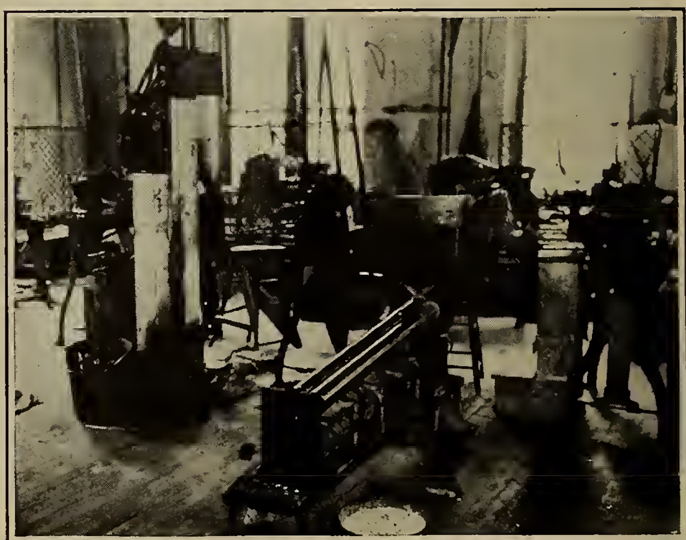
The blank cutters are paid upon a grossage basis, and therefore, it is to their advantage to produce as many blanks in the course of a working day as possible. To utilize each shell as far as practicable these men cut out discs of divers diameters, and for that reason it is needful to assort the pailfuls of miscellaneous blanks. The blanks are classified according to diameter and thickness; and there are sorting machines which are able to separate at one time blanks of five dissimilar thicknesses. These apparatus are modifications of the double-roller affairs that first sized the raw shells. There is a further classification which groups the blanks agreeably to their quality. When the blanks have been duly sorted they are put in revolving drums, partly filled with water, where the hundreds of discs rub against one another and wear away their rough edges.

Up to this point the blanks still carry the unsightly "bark" of the outer surface of the original shell. This dark epidermis or coat is removed by revolving emery wheels in the grinding department, and the machines that do this work are built so that they can be adjusted to grind the blanks to any prescribed thickness. Once more the blanks are soaked, this time for three or four days. After that the embryo button is sufficiently softened to undergo the machining which rounds off the edges of the disc, scores out the characteristic depression in the middle of the face, and drills the holes in the center, two or more, depending upon the type or pattern.

American genius has devised automatic shaping and drilling machines each of which can produce in the course of a working day more than 150 gross of buttons. These apparatus are marvels of precision, and it is necessary that they should be. Drilling the holes or eyes is a very important operation in the making of pearl buttons, and if these were not spaced exactly the buttons could not be used in the button-sewing machines which are so extensively employed in certain branches of the garment industry. The shaping and drilling mechanisms have been so perfected that they do what formerly required three distinct hand machines. The blanks are fed to chucks, revolving under a sharp knife, which cuts the pattern. Next, the chuck carries the button along to a spindle in which is set the drill which bores the eyes. When these are finished the button is moved to the intake of an air-suction pipe, where the impulse lifts the button out of the chuck and drops it into a bucket underneath the apparatus. But the pearl button has not yet completed its evolution; it must still be subjected to



THE MACHINE FOR "FACING" THE BUTTONS



THE APPARATUS THAT DOES THE POLISHING

several treatments before it acquires that characteristic appearance which appeals to the ultimate possessor.

The shaped and duly drilled buttons are next sent to the polishing room. Upon the thoroughness with which this finishing work is done depends the pearly luster of the marketable buttons. First, the buttons are put in rotating metal churns where they rub against one another until their surfaces are smooth, and when this stage is reached they are shifted to polishing barrels, which also revolve, where they acquire the desired gloss. Attrition alone does not achieve the results. The smoothing churns are charged with a solution of sulfuric acid. This is weak at the start and gradually strengthened. At the end of an hour and a half the buttons are transferred to other churns where they are acted upon by hydrochloric acid for a couple of minutes. It is this acid that gives them their beautiful sheen. Having been washed with steam and water, the buttons are put in the polishing barrels which contain sawdust, and here agitation removes every trace of acid and the buttons are buffed by the woody material until they shine. This concludes the manufacturing process of the natural-colored pearl button.

Some pearl shells require bleaching, while the buttons made from others cannot be bleached, and these, by a special process, are tinted and become what are termed smoked pearl buttons. The present-day demand for buttons to match the hues of dress fabrics and the call for purely decorative buttons have led to the development of coloring methods. Aniline dyes are used for this purpose, and pearl buttons can now be tinted to harmonize with any shade of any textile. Buttons of this kind have an embellishing charm which is quite distinctive.

The work on buttons is not ended when they have received the finishing touches of the polishing barrels. It is indispensable that they be gone over and grouped according to their several grades before they are carded and boxed. It seems that some batches of buttons may be composed of as many as fifteen different grades, and their sorting is left to experienced, keen-eyed operatives who are alert and mindful of the slightest imperfection. Nimble-fingered girls are relied upon to do this. For the so-called cutting-up trade-manufacturers that turn out ready-made garments, the buttons are packed loose in pasteboard boxes, while for shipment abroad they are frequently put in cotton bags containing ten gross. For the jobber, however, the buttons are usually sewed on cards. This may be done either by hand or machine. The advantage of machine sewing is that it permits the removal of a button at a time without releasing the others on the card. For the sake of those interested, buttons differ in diameter, *i.e.*, size, by a measurement of lines, each line being one-fortieth of an inch.

As might be expected, the scrap shells from which the blanks have been cut would become an unprofitable waste if ways had not been devised to utilize the stuff. The shells are now extensively crushed and ground, and so treated they become an excellent poultry feed. The material serves the twofold end of grit and lime, the latter aiding in the formation of egg shells. The pearl-shell dust possesses properties which make it well worth while as a fertilizer; and this plant food has proved especially beneficial in the cultivation of alfalfa. Abroad, the meat of mussels, when dried and ground, has been discovered to be of notable value in the stimulation of egg production. Used for this purpose, the meat from the bivalves gathered by the pearl and pearl-shell fishermen would most likely render a greater profit as a chicken feed than as a food for hogs; this, of course, provided enough of the raw material were obtainable regularly to warrant the installation of the needful drying and grinding machinery.

The U. S. Bureau of Fisheries has given serious attention to the propagation of fresh-water bivalves suited to the manufacture of pearl-shell buttons. Eleven years ago the Government established a Biological station at Fairport, Iowa, where it carried on experiments in connection with fish that, at a certain stage, assist in the nurturing of the infant mussel. Other stations were subsequently instituted, and it is now known that mussels or clams can be propagated on a commercial scale and brought to a maturity fit for the requirements of the button maker in two or three years. Artificial propagation can be counted upon to improve the industry inasmuch as this procedure will render it practicable to promote the cultivation of the more valuable species of shells. There is no reason to fear that our manufacturers of buttons from fresh-water shells will ever lack a supply of the basic raw material.

DRILLING THE HOLES IN THE BUTTONS

Our fresh-water pearl factories have brought about a profound change in our domestic button business; and it has been declared that in the course of two decades buttons from the clams and mussels of our inland rivers have saved Americans the tidy sum of fully two hundred million dollars, and all because buttons made from pearl shells of oceanic origin are more expensive. But the industry represents something else of economic importance: it has shown us how we could utilize forms of aquatic life that previously were well-nigh totally neglected.

But let us not lull ourselves into the belief that this comparatively new field of activity is secure for the future because of the mere fact that we have created effective special machinery and that our river beds can yield us an abundance of suitable bivalves. We must bear in mind that labor charges constitute the biggest single item in the cost of turning out an acceptable pearl button. The Japanese are rapidly adopting our mechanical methods and duplicating American apparatus, and they are able to obtain skilled workers for a daily pittance that is only a trifle of what we have to pay here for the corresponding laborer or craftsman. This situation is one that calls for serious consideration on the part of our tariff experts. Domestic enterprise has enabled us to hold our own against the competing button makers of Europe, and we have benefited. It is equally essential that this typically native line of endeavor be protected against the menace of low-priced labor of the Orient.

Between the Infinites

An Essay Upon the Impressive Magnitudes Which the Universe Presents

By Hudson Maxim

THE way of life is along a narrow ledge between the infinitely great and the infinitely little. Topless heights tower above and bottomless depths yawn below. We have forgotten whence we came, and mists of uncertainty shut out our view of the beyond. Belief in our own size and importance depends upon the narrowness of our horizon, for just in proportion as we become aware of the immeasurability by which we are surrounded do we become conscious of our very littleness.

The savage who sees earth and heaven meet at a distance of only a few miles imagines that his inverted bowl of sky covers the universe — that fortunately he is situate in the very center of it; and he may well swell and strut with self-importance. But when he climbs a high mountain, and finds the land stretching away, an eye's mighty reach, before it joins the sky, he is forced to readjust his opinion of the size of the world. It is bigger than he thought, and a question is born in his mind that possibly, could he mount still higher, the horizon would again be greatened. Similarly, the scientist, climbing the heights of knowledge, finds that he must constantly readjust his opinion of the size of the world and of the universe to accord with his changing points of view.

Some weeks ago the senior member of our staff and the Einstein Editor were discussing with Hudson Maxim certain aspects of the relativity theorics, when the inventor produced from his files an essay which he had written several years ago for an almost forgotten paper of very short life, the Times Magazine, but which he had never put into a place where it would be generally available. Many people have written with more or less understanding and literary skill upon the appealing subject of the infinite; but Mr. Maxim's essay appeared so far and away the best thing of the sort we had ever seen that we took it right away from him for publication in our columns. It is seldom indeed that in the more or less hum-drum procedure of chronicling scientific and mechanical progress we have the opportunity to present a piece of literature of such high order as this.—THE EDITOR.

Impelled by his powerful passions, appetites and needs, man, through the ages, has been grappling with the forces of nature to understand and conquer them to his use. The desire to investigate and fathom natural phenomena — a desire grown with us through the ages — the desire to go with the imagination into the great heights and depths of things and bring back knowledge from the remotest shores of the knowable, has now become a passion. The advance of cold, calculating science need not make us fear for the old wonder-world whence we are emerging, as a playground of the imagination; for even today the magic wand of old Mystery halts gray-haired Science confounded on the brink of the unknowable, and he reaches to take hands with his mystic brother, while together they peer into the depths where are new and greater wonder-worlds. The wonder-science which we inherit from the long ages is stronger with us than the new-born science of reason. Modern science is a parvenu.

All pleasure is due to the exercise of faculty; hence when any faculty is exercised in an unusual degree, but in a less degree than will injure the faculty, the exercise serves as a tonic. We are exhilarated by looking from a great height upon surrounding landscape, because the faculties brought into play are doing unusual duty. Similarly, anything which gives us a new or deeper view of the mystery of things exhilarates us through the imagination. The keenest delights of the scientist and philosopher arise from the contemplation of stupendous magnitudes, or of littleness that transcends understanding, and in trying to fathom the depths of environing mystery where science has not yet penetrated. Sublimity in poetry, power of oratory, and much of the force of every-day utterance depend upon the use of potential words and forms of expression which stimulate perception of magnitudes. Eliminate from Milton's "Paradise Lost" all that stimulates by the contemplation of magnitudes and it would be without sublimity.

To Herbert Spencer the thought of endless space was an obsession. That space is endless is an awful thought. That space has an end is inconceivable and we are certain that there is no end. Similarly, we are certain that time is without beginning and without end.

Though encompassed on all sides by infinitude, by a vastness which we cannot now understand, and may never hope to understand, still there are many truths of which we may be as absolutely certain as of our existence. For example, the laws of physics. Assured of these fundamental truths, possessed of this primary knowledge, man, though but an infinite mite on an infinitely little world — a mere point relatively of inconceivable minuteness in immensity — is able to understand the ways of the stars that shine on him from the bottomless deeps of infinitude, able to weigh suns a thousand times as great as his own and a million times as far away, and to discover their chemical nature from analysis of their light — light which left them before the Egyptian pyramids were builded, or China had a history. He can tell us the temperature of Sirius as compared with that of Arcturus, using an instrument so delicate that it will measure the heat of a candle-flame nine miles away. Man has made an open book of the geologic strata of the earth, and has unraveled his own history and traced his pedigree back through the descending stages of animal life down to the moneron, a speck of protoplasm born in the azoic sea. Man has penetrated the future, not with prophecy, but with fore-knowledge that sees our sun burnt out and the earth dead in the sepulcher of time; and beyond that death, man believes he knows that, far down the ages, an inconceivable and to us practically endless time, a new solar system shall be born of ours in some great stellar collision, where a new earth among new satellites may be peopled by another human race.

All celestial processions are in cycles. Hence, it is not only possible, but probable, that somewhere in the universe today there are other worlds similar to our own, with similar beings upon them. We have only to realize that space is endless to appreciate that there is plenty of room; have only to realize that time is endless, to appreciate that there is plenty of time, and that forces are infinite for infinite possibilities.

Our conceptions of the great and the small are only relative. When a twelve-inch cannon, charged with smokeless gunpowder, is fired, the time that elapses between the flash of ignition and the instant the projectile leaves the muzzle of the gun is about the sixtieth of a second, a period so brief that to our sense it appears instantaneous.

Sixty such cannon could be arranged side by side and discharged by electricity, one after the other, within the time of a single tick of grandfather's clock.

The rate at which smokeless powder burns in a gun, under the high pressure, is about the sixtieth of an inch in the sixtieth of a second, or about four inches per second, and this we call slow-burning in smokeless-gunpowder parlance. The rate of combustion of high explosives, such as dynamite, is much higher, being about four miles a second. The pressure exerted by Maximite, nitro-gelatin, nitroglycerin, picric acid, and other of the most powerful high explosives at the instant of detonation, is estimated to be between three hundred thousand and five hundred thousand pounds to the square inch.

Great as is this enormous pressure, and great as is the speed of the detonative wave, we have, in studying the structure of the universe, to consider forces which make these seem insignificant.

We frequently hear the theory advanced that planets and suns explode; and that our own earth might possibly explode from pent-up forces within. A high explosive exerts about the limit of pressure capable of being exerted by gases set free and expanded by the heat generated by any chemical reaction. Such a pressure, great as it is, is far too insignificant to explode this earth. Were the whole great molten interior of our globe to be replaced by dynamite and detonated, the explosion would not lift the earth's crust. We have but to calculate the weight of a column of granite of a height equal to the thickness of the crust of the earth, to see that the pressure of the crust on the molten interior far exceeds the pressure exerted by exploding dynamite. We have seen that the speed of the detonative wave is about four miles per second. The speed of the earth in its orbit is four times as great. If therefore, the interplanetary space of our solar system were to be filled with an explosive mixture capable of being detonated and consumed with the speed of dynamite, and if this were to be set off just behind the earth in its orbit, the earth would not feel it, but would rapidly rush away from the wave of explosion, pass clear around the sun, and come back again to meet it more than six months later. It would take nearly a year for such a detonative wave to reach our sun from the earth. If the earth itself were a ball of dynamite, it would require half an hour to explode; and if the sun were a mass of dynamite, it would require about two and a half days to explode.

The flight of the earth in its orbit is very slow, however, compared with the speed of many other heavenly bodies. Meteorites frequently have a velocity of fifty miles a second. A sun moving at a speed of from four to five million miles a day is not thought by astronomers to be exceeding the speed-limit. One sun is known to be moving at about seventeen million miles a day. Suns moving at the rate of four to five million miles a day, though but a moderate distance away compared with other stars, are still so remote that since the foundation of Babylon they have not moved along the sky an apparent distance greater than the diameter of our moon. A celestial body moving at an average rate of five million miles a day would require more than eighteen days to reach the sun from the earth, a distance of ninety-five million miles. Yet light is so much more rapid in its flight that it traverses that space in about eight minutes. We have seen how slow are the operations involved in the discharge of a cannon, which, though to us apparently instantaneous, are slow compared with the vastly more rapid explosion of dynamite; and again, how slowly moves the detonative wave when, in its turn, it is compared with the velocity of the heavenly bodies. Now we find that even these amazing velocities are a snail's pace compared with the speed of light.

If we could but borrow the wings of light and sail through the universe, what voyages of discovery we could make! But stay—let us do a little figuring. How far could we go and what stars could we visit and return from in our short lifetime? The distance to our sun is sixteen thousand six hundred times the diameter of our earth. Taking this distance which separates the earth from the sun as unity, for a celestial yard-stick, the nearest fixed star, Alpha Centauri, is two hundred and seventy-five thousand times that unit. This is our nearest solar neighbor, and our next nearest neighbor, 61 Cygni, is almost twice as far again—nearly five hundred thousand times our celestial yard-stick. If we conceive an enormous hollow sphere, with our sun in the center, it would require a diameter of nearly a million times the distance to our sun to enclose 61 Cygni. There would be only two stars besides our own in this enormous void. It would take us, moving with the speed of light, more than four years to reach our nearest neighbor, Alpha Centauri, and almost twice as long to reach our next neighbor, 61 Cygni. It would require thirty-four years to reach Arcturus; a lifetime of threescore years and ten to visit Arcturus and return.

Remote as are these stars in the depths of infinitude, they are relatively our next-door neighbors in comparison with the great mass of suns lying beyond, whose numbers are known to be more than a hundred millions. Some of them, whose lights are too dim to be seen through the most powerful telescope, are revealed to us by the photographic plate. It has been estimated that the faint rays reaching us from some of these stars left there fifty thousand years ago—thousands of years before Niagara had begun to cut its gorge. What mites we are! Yet it is a consolation to know that the warmth of the cheek of our fair lady and the reflected light from her beautiful eyes are felt in Arcturus; or rather, will be felt in Arcturus thirty-four years hence. The light she places "in the window for thee" pierces not only our little night, but goes on forever through the night of immensity, eddying around dead old suns lost in infinitude. When a fly lights upon your hand, the whole earth moves to meet it a distance exactly proportionate to the fly's mass.

Again, considering ourselves introspectively, it is a consolation to know we are so wonderfully constituted that no image of any object which has rested upon the retina of our eyes is ever wholly effaced from memory, either conscious or subconscious. No sound is ever completely obliterated—no thought but lives as long as we live. Thoughts, images, and impressions, though far beyond recall by the conscious mind, and individually too faint to exert a material influence upon us, still, in the aggregate, with many millions of other and similar impressions, go to make up that ponderable subconscious experience which underlies our character.

Meteoric dust glows upon us from a vastly distant nebula; and the light of an individual particle of that nebula, though utterly imperceptible, and all but utterly lost, still contributes its individual part which, combined with the billions of others, reveals its presence to us.

Just as one person's memory exceeds that of another, so does one person often far exceed another in his powers to recall into consciousness and to utilize his subconscious powers. Such persons are said to have powerful imaginations. The imagination is the playground of reason; and when we set our fancy free and follow her leading, we penetrate immensity with a pace that makes even light a slow-coach.

Had we eyes of infinite powers, and could we fly outward through space at a sufficiently high rate of speed, we should overtake the rays of reflected light which left our earth thousands of years ago, and as we went we could look back and behold the history of our earth unravel, see the return of man to the ape-like thing, see him and all animate forms finally converge upon the moneron plunged in the azoic sea. The effect would be similar to that of the cinematograph, when a course of events is reversed upon the screen by running the tape backward, which makes the divers who have plunged from a height into the water seem to plunge up backward, heels first, upon the platform from which they descended. It is an extraordinary fact—nevertheless a fact—that the reflections of all these antediluvian saurians who lived in the earth's infancy are still moving onward somewhere in immensity, and could we be there, with infinite eyes, we could still see them plunging about in the ancient ooze. Strangely intermingled are the infinitely great and the infinitely little.

We have already remarked the dependence of sublimity in poetry and the power in oratory upon the potential words and forms of expression which stimulate the imagination through the contemplation of magnitudes. Let us, for convenience' sake, picture ourselves taking flight from our infant planet to make a voyage of discovery through infinitude, restricted in our speed only by the necessity of threading our way among the stars, and we have an opportunity for about the limit of the possible in picturing and contemplating vast magnitudes of time, space, power, and mass.

Could we actually travel at the speed of thought, that is to say, could we reach any star on the instant of thinking of it, our speed would be limited only by the time required to think of one star after another in their order, thinking first of the stars lying nearest in the line of flight, to avoid colliding with any of them, which would occur if we first thought of a star lying just behind another.

Could we go out through the spangled universe with such inconceivable velocity as this, the fixed stars on either side would appear to rush by us with such velocity as to leave streaks of light upon the surrounding dark, while the stars lying directly in front of us would appear to burst from the dark and to disappear with the rapidity of a flash of lightning. The effect would be similar to a great flash of sheet-lightning at night on the face of a black storm-cloud.

Celestial dynamics present some strange paradoxes. We have learned that the condensation of a nebula evolves heat, that is to say, the more the nebula condenses, the hotter it gets. This heat is being continually radiated into space, causing still more condensation with the evolution of still more heat. In other words, the more a nebula is cooled off, the hotter it gets, until we have a solar system with an incandescent sun in the center, with planets revolving round it which broke away from the rotating mass during the process of shrinking. The planets are at first incandescent, but being smaller than the central mass, lose their heat more quickly, the smallest planets losing their heat first. The sun still goes on cooling and shrinking and still growing hotter and radiating heat into space until it passes the critical point when it changes from a gas to a liquid, when no further heat is produced by further shrinkage. Then the sun going on cooling, passes from the liquid to the solid, from incandescence to red heat, and from red heat to blackness and death. The enormous black mass sweeps on through the infinite night, with a velocity so tremendous that when it encounters, which it is sometime certain to do, another celestial body of nearly its mass, or exceeding it in mass, and moving at a similar velocity, sufficient heat is generated by the impact to convert both participants in the collision into a mass of incandescent gas so inconceivably hot that it is quickly expanded far out into space, and when expansion has ceased, the work required to propel all the particles of the mass outward to the positions they then occupy is exactly equal to the energy developed by the collision. We have again a nebula and it is infinitely cold, but not quite as cold as outer space; hence condensation begins again—a new creation begins.

It is frequently necessary for the artist to put a man or other animal whose size is familiar, into a picture, in order to enable us to appreciate the size of other objects. In like manner, we are better enabled to grasp stupendous magnitudes by drawing comparisons between magnitudes which we can easily comprehend.

We have spoken of the distance between the earth and the sun as our celestial yard-stick. If we were to represent the universe on such a small scale that our celestial yard-stick would actually be but three feet, a small marble a third of an inch in diameter would serve to represent the sun. The earth would be represented by a small speck one-three-hundredth of an inch in diameter, just visible to the naked eye, at a distance of three feet, while Neptune, our frontier planet, would be represented by another small speck one-eightieth of an inch in diameter at a distance of ninety-eight feet. This would represent our solar system in miniature. And if this miniature solar system were laid out on the smooth cement pavement in front of the City Hall, New York, and we wished to add the nearest fixed star, the double sun Alpha Centauri, it would be represented by two small marbles one hundred and seventy miles distant—for instance, Baltimore, Maryland, while the next nearest fixed star, the double sun 61 Cygni, would be represented by two small marbles placed more than three hundred miles away, or, for example, at Augusta, Maine.

If a twelve-inch gun were to be fired from the earth at Alpha Centauri, and its projectile were to travel to that star at an uninterrupted velocity of twenty-two hundred feet per second, the flash of the gun would be seen there about four years after it was fired, and the sound would reach there nearly four million years later. The projectile, traveling about twice as fast as sound, would reach there in nearly two million years after the flash was seen.

We are unable to comprehend such magnitudes, consequently vastly smaller magnitudes may appal us in an equal degree. For example, the coal in the State of Pennsylvania would, it is estimated, supply the whole United States at the present rate of consumption, for a thousand years. This immense mass of carbon, if precipitated into the sun and burned, would supply its radiant heat for only the thousandth of a second. Again, it would take a row of Niagaras circling the earth three times, with every foot-pound of energy utilized in electrical horsepower, to equal the energy which the earth receives from the sun. In other words, the work which the sun performs upon the surface of the earth, is equal to that which would be required to pump from the ocean water enough to supply a Niagara seventy-five thousand miles wide.

Here is a question with which we may interest and puzzle ourselves to the heart's content, or discontent. We believe, as has been stated, that all celestial processions are in cycles, and behind this belief we have the knowledge that the amount of matter in the universe is a constant, and that the total amount of energy in the universe also remains constant, all changes being due to changes of the relative positions of atoms of matter giving different manifestations of force, all matter being one in the ultimate. We know, further, that there can be no effect without a cause, and that there are no more effects in the universe than are exactly due to producing causes, which causes are due to and are the effects of preceding causes, while all present effects are the causes of effects to come.

Now, therefore, we know that if all the atoms in the universe were to be placed back again in exactly the same positions with respect to one another which they occupied a thousand years ago, possessing the same movement they then possessed, all the atoms would, after the lapse of a thousand years, be exactly where they are today. Consequently, every human event would reoccur exactly as it has occurred during the last thousand years, and we should all again be here and actuated by the same inertia of purpose which impels us to work out our destinies without changing the nature of a single atom or swerving one from its destined course.

The vibrations of the atoms in the minute molecule are governed by the same exactitude as the march of suns. The flight of a comet and its return from the sidereal depths may be calculated and foretold to a day. The solar eclipse is predicted to a second. If we now extend our thousand years until it embraces eternity, what must we conclude? Let us follow the cycles of the suns. Nebulæ are born in the crash of worlds; nebulæ become suns, and these in turn give birth to planets, and planets evolve animal life up to man. Planets grow old, their suns wither and grow cold in the dark sky, where they wander on to a predestined collision with other, and perhaps dead old spheres, coming to meet them out of the great darkness. Then new nebulæ, new suns, new planets, and new men shall come again. Though the time be long, it counts for nothing in eternity. The life of a sun is relatively less in infinite time than the duration of the flash of an evening

fire-fly compared with the life of our sun. Is this appalling thought true then, and we know of no reason why it is not true, that races of mankind have occurred in all past time, and will reoccur during eternity? Their occurrences, therefore, must be infinite in number, and although but an infinitely small portion of the ponderable matter in any solar system ever actually takes human shape, still it requires only time long enough in order that every atom in existence shall pass through the human heart, as it must in the nature of things have heretofore passed. In short, it requires only time enough for it to have passed through the human heart an infinite number of times.

If the cards be shuffled times enough, we may all draw a royal flush, so it is but necessary for the infinite to shuffle the stars times enough to give every atom in existence the royal chance of mounting through the human frame to the dignity of brain, and throne of thought, mind, soul.

ANIMAL BEHAVIOR AS A FACTOR IN THE FORMATION OF BONE BEDS

The occurrence of fossil vertebrates massed together in considerable numbers in restricted areas is a familiar fact to experienced collectors. These aggregations are usually spoken of as bone beds or quarries by collectors of fossils. Various theories have been proposed to account for the surprising abundance of vertebrate remains in certain quarries and their absence or scarcity outside these limited areas. Different kinds of bone beds evidently require different explanations.

In the case of bone beds in which only a single species or closely associated species are present, the accumulation of the remains of numerous individuals may be explained by the peculiar behavior of some animals of the present time on the approach of death from starvation or freezing. Such bone beds appear to be common in the Cretaceous. Mr. C. M. Sternberg is acquainted with "no less than 7 bone beds in which only horned dinosaurs are represented."

Darwin has described the curious instinct of the guanaco of South America which leads it to "have favorite spots for lying down to die. On the banks of the St. Cruz in certain circumscribed spaces which were generally bushy and all near the river the ground was actually white with bones."

A western correspondent, Mr. R. A. Brooks, has given me in a letter a description of the behavior of cattle and buffalo on the western plains under the stress of cold, starvation and fright, which clearly indicates how large masses of the bones of these animals have been accumulated. Mr. Brooks states that: "During the hard winter of 1906-07 thousands of head of cattle perished from starvation and cold. I remember well how some of them died. The first cow to die usually felt it coming and left the bunch or herd and slowly made its way to a lonely place, generally a clump of brush or a coulée, and lying down simply waited to die. The next one feeling her time approaching followed in the tracks of the first one, and died close beside her and this was kept up until there were no more, or relief came. At the U Ranch in the Hands-Hills, central Alberta, the owner showed me a coulée where 450 head of his cattle died. This pile of bones actually made a dam across the ravine. Within half a mile was another pile of bones, all that was left of 675 head. Everyone acted the same way. The owners told me that hardly half a dozen died separately and these were on their way to the dying place.

"There is also another place on the Beaver Dam River where countless buffalo died of thirst during a dry year. An old Indian told me that long ago there had been nearly three years of rainless seasons. All the rivers were dry as well as most of the springs. But one kept flowing very freely on the banks of the Beaver Dam. When a herd of buffalo would come near enough to scent this, there was a stampede for it and the ones behind would literally climb over the front ones and trample each other to death. Prairie fires also were the cause of many buffalo bones at the bottom of cliffs, and it is well known here that in the early days the Indians themselves used to stampede herds of buffalo over the cliffs."

This account of the behavior of western cattle under the conditions described, and the mass destruction of the buffalo when acting under stampede excitement, gives an insight into phases of animal behavior which may have been a factor in the formation of some fossil bone beds. It may be that the Alberta dinosaurs of Cretaceous times when famine came, like the Alberta cattle of today, sought a common dying ground.—E. M. Kindle, in *The Canadian Field-Naturalist.*

NEW POINTS ABOUT PIGMIES

In various parts of Asia and Africa there are found those curious dwarflike races known to anthropologists as pigmies. They inhabit almost exclusively regions lying on the borders of those zones inhabited by other races of men—regions which are either waterless steppes such as those occupied by the bush folk in South Africa, the Kalahari, or else dense primeval forests such as the forest dwarfs of Central Africa, the Andamanese along the Bay of Bengal, and the Negritoes of the Philippine Islands. It is not possible to draw a sharp line of distinction between these races and the rest of mankind since the varying degrees found in the size of the body forms a connection between them and the taller races living near them. These intermediates, however, appear to be the result of racial crossings. Thus, the Senoi and the Semang upon the Malay Peninsula and the Taola of the Celebes Islands, can hardly be regarded as pigmies, though they are undoubtedly closely related to the Andamanese and the Negritoes; they are hybrids between an original pigmy population and later adventurers, and there are constantly found among them individuals who resemble more or less closely other primitive races. Upon the island of New Guinea also the blood of the original pigmies has been mingled with that of the Melanesians who made their appearance later.

The Negritoes of the Philippines are the pigmies which have longest been known to Europeans since the Spaniards came across them in very early times. Before the immigration of the Malays they appear to have occupied the entire group of islands, although today they have been driven to find retreat in remote mountainous forests; they are most abundant at the present time in Northern Luzon, but small remnants of them are to be found on almost all the islands of the Philippine group. They number about 23,000, whereas the Andamanese have been reduced to a population of 2000.

Among the African pigmies the bush folk or forest folk have been almost entirely exterminated, while the dwarfs of the primeval forests from the Cameroon as far as the East African seashore are still pretty numerous and well distributed, for the reason that the dense forest shelters them against both negro tribes and European explorers and settlers.

Thus far the shortest heights found in any grown man are as follows: Negrito, 128; Andamanese, 138; Kung, bush folk, 142; Hei'kum, bush folk, 149; Babinga, 140 cm.

The proportions of the body bear a close relation to the stature in pigmies, especially as regards the great length of the trunk compared to that of the legs. A connection is very generally found between a low stature and childish proportions.

Besides their small size pigmies are distinguished by various other marks, such as the delicacy of the hands and feet, the childish form of the forehead, the convex upper lip and the short, broad ear without a lobe or with a grown-on lobe. . . . The color varies among different tribes, being sometimes a light brown like that of a dead leaf, sometimes rusty black as in the case of the Negritoes, dark brown as in the Andamanese, or even pale reddish yellow as in some of the forest pigmies.

While some authorities have held that pigmies are the result of retrogression in higher races, the best modern view seems to be that this is a mistake and that they are merely admirably adapted to the conditions under which they are forced to exist. They are believed to be older than the taller peoples which live in their vicinity.

MUSCULAR PRECISION AND CONTROL ARE MEASURED BY THESE SIMPLE TESTS

Left: The subject strikes a telegraph key repeatedly, and the instrument registers the degree of success which he attains in his effort to give the same force and the same duration to all strokes. *Right:* In this test for quickness of eye, the plug must be inserted into the hole without striking the rim, else a circuit is made and a bell rung

Psychological Tests of Industrial Capacities

The Methods Employed Here and Abroad for Divorcing Square Pegs from Round Holes

By May Tevis

IN the Middle Ages—the golden age of craftsmanship—when every artist prided himself upon being a skilled artisan and when it was the ambition of every gifted 'prentice to become not only a good artisan but to continue his studies till he might claim the proud title of artist, earnest consideration was given by parents and guardians as to the choice of the most suitable craft in which to launch their young charges. Even among many primitive peoples it is said to be the custom to place various objects of symbolic character, such as an apple, a young animal, and a bow and arrow near a young infant, with the purpose of observing which of these most engaged its attention, so that they might be guided as to his fitness to become a husbandman, a shepherd, or a huntsman.

But the tremendous upheaval brought about during the last two or three centuries in the arts of industry by the rapid development of machinery and its accompanying handmaidens, steam and electricity, occasioned an almost entire breakdown of the old system of guilds with their master craftsman, their journeyman workmen and their apprentices. In their stead we have seen the rise, at first very gradual and more recently very rapid, of the trade unions. These bodies of labor, organized originally for mutual benefit, self-protection, and legitimate collective bargaining, but of late constituting, in the opinion of many observers, as serious a menace to the rights of the public as are the profiteering capitalists at the other end of the scale, have incidentally largely contributed to the decay of the system of apprenticeship, through mistaken jealousies and fears.

These circumstances, combined with various other factors, have led, especially during the last fifty years or so, to great uncertainty and confusion in the minds of youths casting about for some avenue to employ their energies at the outset of their industrial lives. As a consequence there has been an enormous waste of energy through the presence "of round pegs in square holes" and these industrial misfits have not only reduced the earning power of the individual, but have been the source of an enormous amount of economic waste, resulting partly from the lowered yield in units of work and partly from a heavy increase in the expensive item called turnover in factories and business houses.

But at last science has begun to find a remedy for this in the application of experimental psychology to the study of men and women, and particularly of boys and girls for the purpose of discovering the peculiar aptitudes and deficiencies inherent in the individual.

One of the pioneers in this subject was the late Professor Hugo Münsterberg of Harvard University, whose greatest service, perhaps, was the calling of popular attention to the subject, an attention not unmixed with ridicule from the groundlings. Indeed, though the whole subject has made enormous strides in public appreciation, there are still a good many people who profess the methods of the psychologists considerably far-fetched—a fact attested, by the way, by the recent appearance in one of our most popular weekly magazines of a farcical tale written for the express purpose of deriding the operations of an "efficiency expert" called in by the head of a big business to make psychological tests of his personnel, with the result that the cashier was set to run the elevator because of his mechanical thumb, and the elevator man put in the cashier's cage because of his mathematical ear. It is because of such misapprehensions as this that it seems worth while to give a plain statement of some of the methods actually employed for testing applicants both in this country and abroad. That the matter is far from being all moonshine is attested by the fact that many of the most important industrial companies all over the world hire no men without testing them both for their general fitness and (in the case of apprentices and beginners) for their specific suitability to receive their training in one or another line, *e.g.*, as a turner, a designer, a carpenter.

In America, and we believe the same thing is true elsewhere, an especial impetus was given to the matter by the necessity of placing the thousands of men recruited by the army in positions so far as possible where their natural abilities and special training might produce the best results. Here the psychologists came into their own, and were of immense help to the military authorities, in spite of the fact that they were facetiously known among the men as "the nut-pickers." The army tests are too well known to be repeated here, however, and we shall confine ourselves to the somewhat different methods employed for investigating the aptitude of would-be employes. These fall

into two general classes, one consisting of written tests or group tests, as they are sometimes called, and the other of individual tests with or without apparatus. In the first class it is the mental ability which is of most importance, while in the second it is the acuteness of the senses, the coordination of the muscles and the power of the will which count most.

The mental faculties which are of basic import are the power of attention of memory, of imagination, of judgment, of reasoning, and a capacity for making observations. Attention may be instantaneous or concentrated for a longer period of time and both faculties are advantageous. A common test of the capacity for concentrated attention during a given lapse of time consists in giving the subject a printed text in which he is required to strike out certain letters—"a, e, and u" for example. Some subjects are able to do this very rapidly while others are very slow about it, but it must not be thought that the latter case is always due to stupidity, since it may, on the contrary, be caused by a greater degree of conscientiousness. Again, one applicant may work very fast, but be guilty of a number of mistakes, while his slower comrade makes very few or none at all. Another point brought out by the experiment is that some applicants have their errors pretty evenly distributed while others show a marked decrease in correct judgment toward the end of the test.

There are various methods, of course, for testing the memory and here, too, there are differences shown since some subjects commit to memory readily but forget promptly, whereas others are slow to learn but display very retentive memories. Occasionally, there is the supposedly ideal memory which is "wax to receive and marble to retain." A common method of testing the memory is to place the same text before the entire group who are undergoing an examination, with the requirement that it be "learned by heart," and later reproduced from memory either precisely or as regards its main points. An accurate and retentive memory is considered especially desirable in the learned professions such as law, medicine, and teaching. The present writer is of opinion, however, that in some cases a too facile memory may be an actual handicap, leading its possessor to depend upon more or less well digested information, with failure to give the all important powers of ratiocination and imagination due exercise. While many men of genius have possessed prodigious powers of memory, a study of their history will show that their other faculties were equally brilliant and that the memory was employed in its proper function as a warehouse of materials. While teaching a class of small boys some years ago, the writer required them to reproduce in their own language a short selection read aloud to them. It was necessary to give one of the best boys in the class a low mark, since his too perfect memory enabled him to reproduce the selection, not in its main features through the exercise of his original powers of expression, but, on the contrary, almost verbatim. Many other instances will recur to readers of history, of men famous for their vast erudition who, nevertheless, made but little impress upon their times. Such men resemble those unfortunate ants whose fate it is to cling supinely to the walls of the cell with their bodies distended with honey to serve as magazines of nourishment for their more active nest mates.

An intellectual capacity which is extremely valuable in many lines of endeavor, is the power of making *constructive combinations of a technical nature*. Such a power is evidently dependent upon a very complex mental process, and this makes it all the more difficult to devise suitable tests.

What is known as a sense of space, *i.e.*, a correct judgment of spatial dimension, whether by the eye or by the coordination of various muscles in the hands and arms or legs and feet, is a very important matter not only to engineers and architects, but also in large measure for mere workmen, mechanics and laborers. Such a faculty, for example, is very useful to a man in comprehending mechanical drawings and specifications. It is a matter of common observance, indeed, that men in whom this space sense is strongly marked, quickly advance above their less gifted fellows. A common way in which this capacity is tested is to send the subject being examined to select tools according to a certain pattern, for example, he may be given a technical drawing showing a simple screw nut in side view and in section. He is told that he must pay special attention to the form of the outline but need not consider especially the more lightly traced lines giving the dimensions. He is then sent to select the given tool from among a large number, some of which are very like it while others are more or less different lying together upon a table. Here again some applicants make the correct selection easily and promptly while others are slow and hesitating in their choice. The unskilful, those lacking in power of attention, make many mistakes—for example, instead of bringing the nut which they were asked for they may select a spiral spring because it was mentioned to them that the nut had a spiral thread, and because their memory as to the outline was at fault.

In many trades delicacy of tactile perception is extremely important. A relative of the writer who eventually became very wealthy remarked in speaking of the outset of his career that he had voluntarily resigned an excellent position with a wholesale dry goods company for the reason that he found his sense of touch insufficiently sensitive to discriminate between various grades of woolen, linen and cotton goods. Few young fellows of his age, however, have sufficient self-knowledge and forethought to make such a decision for themselves, hence it is cus-

FURTHER LIGHT ON THE RELATION BETWEEN STIMULUS AND REACTION IS GOT FROM THESE TESTS

Left: Perception and reaction intervals are tested here, where the boy must let go the switch on the appearance of a certain light among the many on the board before him. *Right*: Another test similar to the first one pictured; here the subject tries to give repeated hammer blows with exactly the same force

tomary to make tests both as to the sensitiveness of the touch, and of the joints, whose suppleness and precision of action is also of great importance in all those trades that involve the handling of materials, as in the case of carpenters, joiners, turners, etc. In psychological laboratories this faculty is frequently tested by means of a bolt fitter. This apparatus consists of two concave chucks which are made to approach or recede from each other by means of a wheel turned by hand. The subject is told to turn the wheel until the bolt "fits" the cavity enclosed by the chucks, *i.e.*, until it arrives in a certain precise position, which is minutely described to him previously in the simplest and most unmistakable terms. Here again we observe that some boys or men are able to place the bolt in the right position almost immediately. This placing of the bolt is repeated several times and the degree of accuracy is read each time on a hundred-millimeter scale. By averaging the results with allowance for certain "subjective" errors, the general degree of sensitiveness in the articulation of the wrist is found.

Clearly enough there are certain forms of tests and questions which can be better given by practical mechanics, foremen and managers, than by professional psychologists, but it is more and more becoming to be understood that the cooperation of these two classes of men, together with that of men grounded in economics, is requisite for the obtaining of the best results in this field. This is very ably brought out in a recent book by Dr. Henry C. Link, entitled "Employment Psychology," in which two sets of ten questions each were prepared for candidates for the position of gun assembler. The first group of questions with a typical set of satisfactory answers follows:

1. Q. What experience have you had as a gun assembler? A. More than five years on various makes, both rifle and shotgun.

2. Q. What experience have you had as an assembler other than on guns? A. Several years' experience on sewing machines and typewriters.

3. Q. What kind of work requiring particularly close filing have you done? A. Small tool-work.

4. Q. Have you any trouble with your eyes? A. No.

5. Q. Are you nervous? A. No.

6. Q. Have you had such experience in shooting guns as to be able to determine the requirements of a finished gun? A. Rifle. target, and shotgun practice.

7. Q. How long have you held each job? A. More than a year.

8. Q. What are your habits? A. Sober, and never lose my time.

9. Q. Have you had much trouble with the foremen for whom you worked? A. No.

10. Q. Does gun assembling particularly appeal to you? A. Yes.

The second set of questions, with typical answers by the same candidate, was as below:

1. Q. What experience have you had as a gun assembler? A. More than five years on various makes, both rifle and shotgun.

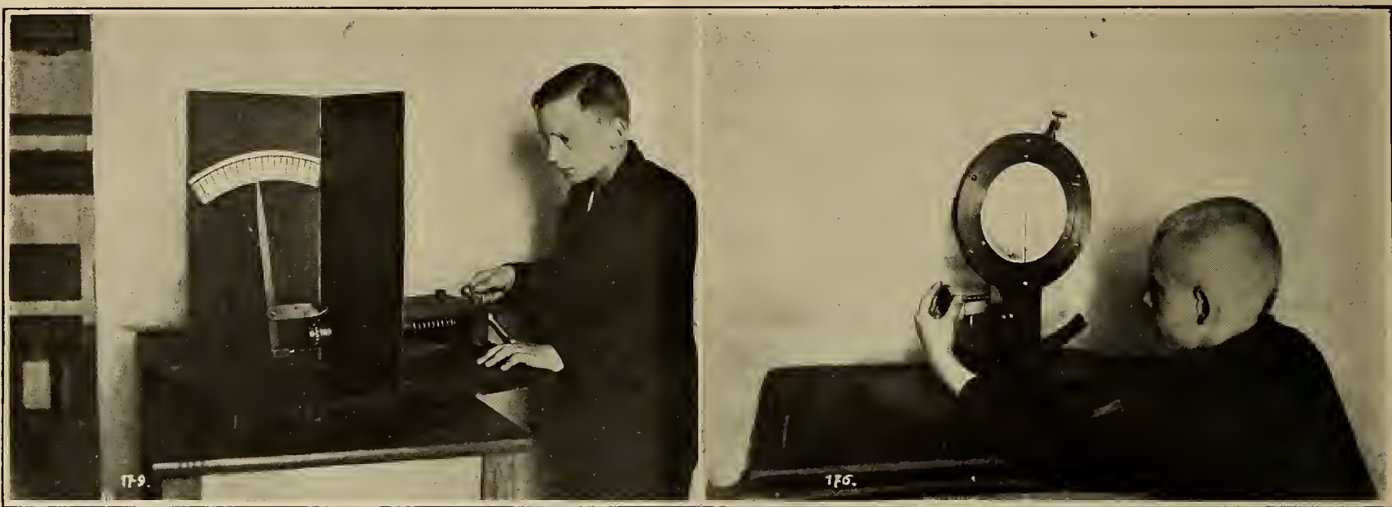
2. Q. Name the most important adjustments on a gun. A. Breeching, locking, trigger, chamber, firing pin, barrel and sight alinement.

3. Q. Why do you consider breeching important? A. Because if the gun is not breeched correctly the cartridge will be loose and cause unnecessary wear on chamber.

4. Q. Why lock? A. If a lock is not correctly adjusted the gun may fly open and injure the operator while shooting.

5. Q. Why trigger? A. If trigger pull is too light, gun may jar off and injure some one, or if too heavy will cause poor targeting.

6. Q. Why chamber? A. If the chamber is too large the shell will swell and cannot be extracted in the regular way.



TESTS IN WHICH THE SUBJECT'S CAREFULLY FORMED JUDGMENT IS INVOLVED

Left: : The boy is asked to turn the screw several times through exactly the same distance, and his success measured by the advance of the pointer over the scale. *Right*: The would-be apprentice in the machine trades must be able to set up a right angle with the two pointers without material error

7. Q. Why firing pin? A. If the firing pin is too long there will be the danger of premature fire; if too short, of misfire.

8. Q. Why barrel? A. If there is a seam in the barrel when shot it will burst open, and if the barrel is not straight the gun will not shoot straight.

9. Q. Why sight alinement? A. The alinement of sight is essential to correct shooting.

10. Q. What experience as an assembler other than on guns? A. Have had several years' experience on sewing machines, typewriters, etc.

11. Q. What kind of work requiring particularly close filing have you done? A. Small-tool work.

These are valuable questions, because they require specific answers about concrete and specific elements in the work of gun assembling. However, definite as they are, they could not be used as they stand with any certainty as to their value. It is first of all necessary to experiment with these questions on a sufficient number of men actually engaged in the work, in order to find out whether the questions are such that the best workers obtain the highest grade in the test, and the poorest workers the lowest grade. In other words, it is necessary to find the correlation between the performance of the men in the test and their actual ability at their trade. Moreover, it is also necessary, by a careful process of trial and error, to eliminate ambiguous words, catch questions, "guess" answers, and

questions which permit a lengthy or indefinite explanation. In short, trade tests, whether in the form of questions or any other form, must be developed, by means of the technique of psychology if they are to be at once practical and reliable.

A further development of the question method is to base the questions asked on pictures or blueprints. A tool maker, for instance, might be shown a group of blueprints calling for operations on different machine tools and asked to name, off-hand, various machines which are required for each. A machinist might be shown a picture of a collection of machine parts and asked to name them. A third method is to give the applicant an opportunity to demonstrate his ability by giving him some representative task to perform.

In formulating and standardizing tests for trades and other technical occupations, too much emphasis cannot be placed upon the close cooperation between the technical expert and the psychologist. The former alone can supply the facts necessary for the meat of a test. However, it is equally true that the technical expert cannot, as a rule, use his knowledge in the manner required by an employment test or interview. This deficiency must be supplemented by the psychologist, whose assistance in formulating the details and standards of a test and in giving it an experimental trial is indispensable to its success.

The second list quoted was the result of a conversation between the foreman who formulated the questions of the first list and a psychologist who pointed out to him their inadequacy. The foreman was intelligent enough to perceive the truth of the criticism and expressed chagrin at its character, after which he made out the second list which is clearly far superior.

Perhaps one of the most suggestive ways of indicating in brief the sort of tests employed is to give a numerical list of tests, some of which are of general applicability, while others are required only in special lines:

1. Eyesight test. 2. Card sort (simple). 3. Accuracy. 4. Steadiness. 5. Cancellation. 6. Number-group checking. 7. Tachistoscope. 8. Arithmetic. 9. Card sorting. 10. Hand directions. 11. Oral directions. 12. Context reading. 13. Substitution, letters. 14. Spelling. 15. Handwriting. 16. Three-hole tests. 17. Filing, alphabetical. 18. Filing, alphabetical (cards). 19. Dictation, typing. 20. Grammar. 21. Substitution (numbers). 22. Comptometer adding. 23. Comptometer extending. 24. Filing, topical, etc.

EFFECT OF FEEDING TADPOLES WITH THE THYROID GLAND

One of the most interesting domains of recent physiological research is that of the effects produced in the animal economy by the thyroid gland. The secretion from this gland not only plays an important role in the growth of children but very recently the claim has been made by a well-known psychiatrist that it is one of the factors controlling emotion in adults. So impressed was a learned judge by the weight of this argument that he suspended judgment in the case of a woman arrested for shoplifting in a New York department store, because of the abnormal condition of her thyroid gland, and physiologists are now awaiting with interest the result upon her morals of treatment of this abnormality. In this connection it may be of interest to give a brief description of some recent experiments concerning the influence of this and other internal secretion glands upon the growth and development of frog larvæ. The well-known German physiologist, E. Abderhalden, and his colleague, O. Schiffmann, have described some of their recent work along this line in *Pflügers' Arch. f. d. ges. Physiol.* (Berlin) Vol. 183, pp. 197-209, 1920, an abstract of which we take from *Die Naturwissenschaften* (Berlin) for April 8, 1921.

It was the object of the experimenters to study the influence of certain substances by histological methods. The external alterations of the growth and development of the tadpoles gave results corresponding to those described earlier (See Romeis). Fresh human thyroid glands were fed to the tadpoles in the form of three extracts which were prepared in different manners and which produced practically the same effects, but in varying degree. The alterations in the intestine were made the subject of special study. The animals fed upon the thyroid gland exhibited an alteration both in the course and in the final result of the metamorphosis of the intestines; and while in the control animals the epithelial cells of the intestine which degenerate during the process of metamorphosis contained only a few thick lumps, varying from yellow to brown, in the case of the animals experimented upon these lumps or masses formed a principal sign of the degenerating epithelium. In the control animals nests of cells are found behind the epithelium and the new epithelium is produced by these. But these masses of cells are lacking in the thyroid-extract animals. In the latter the remainder of the old epithelium appears to draw together again and thus form a new epithelium and later, by reason of this, the degenerating masses find their path into the intestine lumen. These masses were first gradually absorbed into the wall of the intestine. The influence of the thyroid-gland feeding upon the endrendocrin glands was especially studied, exact measurement of the thyroid gland, the thymus gland and the hypophysis being made, and their magnitude compared with that of the brain and of the diameter of the animal. These experiments, however, led to no satisfactory result, since even in the control animals there were considerable differences of size.

TOTAL REFLECTION OF LIGHT IN WATER BY ANIMALCULES

It is natural to suppose that light penetrates clear water as it does glass. The Prince of Monaco, one of the greatest students of marine life, has shown, however, that there are myriads of animalcules in sea-water and that they cause almost a total reflection of a beam of light projected into the water. Therefore, water is not like glass in its transmission of light.

In connection with submarine detection studies, Mr. Elmer A. Sperry, member of the Naval Consulting Board, made some elaborate experiments on projecting light through water, from which instructive results were obtained. An electric light was used having a sixty million candle-power beam, which could be seen through air for 62 miles (150 amperes, 75 volts, condensed and directed by a 36-inch projector).

This light was placed in the bottom of a steel well resembling a boiler 25 feet long, with an opening in its side near the bottom 40 inches in diameter, in which a plate-glass window one inch thick was sealed. There were several tons of lead in the bottom of the well so that it would sink vertically to any desired depth. It was hung by a bale from a crane on a large barge.

The light was first tested in the muddy waters of the New York Navy Yard, at a depth of 10 or 15 feet below the surface. There was a total reflection of light, but this was attributed at that time to the great muddiness of the water. A luminescent sphere approximately 80 feet in diameter surrounded the window. This luminescence was wonderfully brilliant and acted like a fog to obscure vision. Brilliancy of luminescence seemed to be about the same at all points of the sphere, even exactly back of the well in the rear of the window through which the light was projected.

Experiments were then made in clear ocean water near the easterly end of Long Island. Here also it was found that the beam of light could not be projected through the water as had been hoped, and that a globe of luminescence was produced as in the experiments in the New York Navy Yard. The globe of luminescence was visible through this comparatively clear water for possibly a quarter of a mile, and it could be used for the purpose of silhouetting mines, anchors, cables and other objects of this nature, against its white background with very great distinctness, up to this distance of a quarter of a mile.

The Significance of Size*

How Magnitude Conditions the Functioning of Living Organisms

By Dr. Otto Hartmann

IT is quite natural, of course, that the smaller animals should in general be more amenable to external influences than the larger ones, since both their muscles and their skeletons are lighter and more delicate. Few people realize, however, that the absolute size of any living organism, whether plant or animal, is by no means a matter of indifference. Consider, for instance, a blade of grass, which is possibly 1 m. in length and 2 mm. in thickness. Now imagine this multiplied by 10, so as to be 10 m. tall and 2 cm. thick. We see at once that such a gigantic grass blade would be liable to be broken by the lightest breath of air or even by its own weight. The lesson to be drawn from this example is that when any given organism is increased proportionately in all its dimensions, length, breadth, and height, the purely physical conditions which control it may be thereby altered so as to prevent it from being viable, i. e., capable of continuing its existence.

THE ECONOMY OF ANIMAL HEAT PRODUCTION

Let us first consider the production of animal heat. It is obvious that the warm-blooded animals possess internal stoves, so to speak, which enable them to maintain the bodily temperature at a given point, even when the air or water which surrounds them is much colder; the loss of heat abstracted by the colder medium is compensated by the animal heat produced by chemical changes in the body. The more rapid this loss of heat the greater the efforts of the animal must be to replace it. It is evident that this loss of warmth, due to a colder medium, takes place only upon the surface of the body, and because of this that it must increase as the amount of surface increases. But the heat *production* of the body takes place within the interior of the latter, in its tissues, muscles, glands, etc., and must correspond, therefore, roughly to the *volume* of the creature — just as a stove produces more warmth the bigger its fire box, while it gives off more the greater its surface. A moment's thought will show us, therefore, that if any given animal's size be increased to tenfold, the surface will be increased according to the square, whereas the volume will be cubed. The relation of the surface to the volume is altered, although the animal has not been changed in form. Obviously, therefore, if we have two animals of like form but different size, the greater of the two will lose less warmth in comparison to its heat production than the smaller.

As a matter of fact, indeed, there is in the case of very small animals a really enormous surface radiation of heat in comparison to the heat generated by the body; thus we see that warm-blooded animals cease to be capable of living when the size becomes too small for the volume of the body to produce enough heat to make up for that radiated from the surface. On this account the smallest warm-blooded animals in existence, such as the dwarf shrew-mouse and the humming bird, must have a tremendous power of generating heat — a power supported by the food they consume. This at once enables us to understand why these small creatures require such enormous amounts of food in comparison to their size, and why they can support hunger for a much shorter time than larger animals can. This explains, too, the provisions against the winter cold so often found in birds and small animals — such as hibernation, refuge in caves and hollows, or the huddling together in crowds so as to reduce the surface radiation as much as possible. When birds slumber they protect their legs as much as possible by their plumage and stick their heads under their wings, thus assuming a nearly spherical form — a very significant fact, since the sphere has the smallest surface compared to its volume of any solid body.

THE ECONOMY OF WATER

Not only heat but moisture is constantly given off from the surface of the body, so that small creatures lose more in proportion than larger ones. There can be no direct comparison in this respect, however, since the loss of moisture is largely influenced by the nature of the skin, which is sometimes very thin and delicate and at others thick or well-armored.

There are some cases, however, where its larger proportional surface-area is an advantage to the smaller animal. Everyone is familiar with the dusty beam of light seen when sunlight penetrates through an aperture into a dark room. This visibility is due to the fine particles of wood, textiles, earth, etc., which are much heavier than air, but which remain floating in the latter or settle to the earth only very slowly, whereas larger pieces of material fall to the ground at once. The reason for this difference is the comparative proportion of the surface to the volume in the small particles and the larger masses. For example, a wooden ball 1 cm. in diameter will fall rapidly to the ground. If we assume the surface ($6\pi r^2$) and the volume ($4/3\ \pi r^3$) to be originally equal numerically, and then imagine this ball to be reduced in size till it is only one ten-thousandth part as great as before, then the surface will be ten thousand times as great in proportion to the volume as it was before. In a vacuum, to be sure, even so small a ball would fall to the ground as rapidly as the larger one, but the case is very different where the balls are surrounded by air or by water, for here the element of friction comes into play, and this is dependent upon the surface. This consideration explains at once why all organisms whose existence is passed floating in water, and particularly the minute creations known by the general term of *plankton*, are very small, for even if they are provided with floats in the form of spines, prickles, etc., which tend to prevent their downward fall, still the main condition of their viability consists in their small size. Among birds, too, we find that the larger species are apt to be poor flyers and often desert the air for a life on *terra firma*, as in the case of ostriches, barnyard fowls, turkeys, etc.

MAGNITUDE AND MOTION

As the size of an animal increases, the weight of the body augments much more rapidly than the available power of motion, since the latter is practically dependent upon the cross-section of the muscles, which increases according to the square of the linear dimensions, whereas the weight of the body increases according to the cube. This fact at once explains why insects and small animals are able to leap enormous distances compared with their size. Some of them, such as fleas, grasshoppers, and even small dogs, are able to jump many times the length of their own bodies — sometimes, indeed, a distance a hundred-fold as great — which is quite out of the question in the case of the larger animals.

In the same manner an insect undergoes no danger in falling from a tremendous height, even if its body possesses no protective armor. This circumstance, indeed, becomes a measure of protection, since when pursued the little creature simply lets itself fall from even a topmost bough and then hastily scurries away or else "plays dead." Even small mammals, such as squirrels, will throw themselves from the top of trees many meters high when in danger of capture, whereas larger animals would be crushed by a fall of equal distance.

But when one beholds a large bird slowly describing wide

*Adapted for the *Scientific American Monthly* from *Kosmos* (Stuttgart) for April, 1921.

circles in the air, with every motion expressed in harmonic curves, one is immediately struck by the difference which exists between this sort of motion and that of small birds and insects. The latter dart hither and thither with zig-zag motions, come to a sudden stop, and then fly off again with renewed rapidity. The smaller body, of course, possesses comparatively less momentum and is therefore capable of using its muscular power much more readily for the purpose of stopping, starting, and changing direction, even though the muscular framework is by no means so well developed as in the larger species, and the actual energy of motion is, consequently, far less. In order for large animals to move as skilfully and rapidly as the smaller animals, they would require an enormous muscular system, and this would tremendously augment the weight of the body; so that through these purely physical conditions there must be definite limits to the attainable size and power of motion among animals. The solidity of the tissues also limits the size of animals, and if a large animal were able to check a sudden motion as rapidly as a smaller one can, it would literally risk being torn apart — so important is the inertia of large bodies which opposes any sudden alteration in their velocity of motion.

Every nature lover is familiar with the long-legged spider, the *Phalangium opilio*, which usually spreads its web on walls. It would be a physical impossibility for this spider to exist if enlarged to the dimensions of even a medium-sized mammal. Its long, crooked legs, upon which it supports itself in the midst of its web, would no longer be strong enough to support the weight of the body, but would inevitably bend and break. Moreover, the system of muscles would be too weak to move the enormous body and legs. Of course, the muscles would be enlarged in proportion, but we must remember that the supporting power of the legs and the strength of the muscles increase according to the *square* of the magnitude, while the weight of the body and legs increase according to the *cube*.

Many interesting points present themselves in this connection, whose consideration, however, would demand a discussion of mechanical principles into which we can not here enter. We will merely remark that the *leverage* effects, such as are involved in the horizontal extension of the wings, feelers, etc., of insects would be so enormously increased by the supposed augmentation in size that the boneless substance of the insect's body would be unable to support the resultant strain. All horizontal extended members of plants and animals, such as limbs and branches, are necessarily small when their substance is soft and tender; when they are large, as in the case of big branches of trees, the material of which they are composed must be tremendously strengthened (as in the woody fiber of trees).

From the above remarks we see that manifold possibilities in the form and method of construction are open to small creatures which would offer insuperable difficulties from the technical point of view to large ones. This is why the many bizarre and monstrous forms found in small creatures are forbidden to large ones. Engineers, too, are familiar with the fact that the construction of small models is often quite an easy matter, whereas to develop them upon a large scale presents serious technical problems which can often be solved only by some new method of attack — in any case a simple enlargement of small models is quite out of the question. Static problems which are quite insoluble in the case of large animals simply do not exist in that of small ones. Flies, for instance, are capable of crawling up smooth vertical walls because the force of gravity is readily overcome by their muscles and joints, supported by the protective chitin shields of their legs. But the resistance to the force of gravity would be out of the question in an animal a hundred times as big.

Small creatures are afforded an infinite variety of modes of existence merely through their size. What makes it possible for the long-legged water-flea to run lightly over the surface of a sheet of water? If we observe it closely we see that the end of each of its six long legs makes a slight depression where it rests upon the surface. The surface is elastic in fact and acts like a spring mattress. This physical basis of this mode of action may be explained as follows: The separate molecules of water cohere with considerable firmness and therefore offer a certain degree of resistance to penetration by any solid body — but this is true only in case the said body can not be *wet*, i. e., if it has a composition like that of the *fats*. This resistance is a result of the *surface tension* of the liquid, which acts like a stretched membrane. This is sufficient to support the weight of the water-flea, though it would be practically negligible for ourselves. But while this firmness of the surface of a liquid affords great advantages from one point of view to such small creatures, it is terribly dangerous when looked at from another angle. For if such a small insect becomes wet all over, it is immediately drawn under the "skin" of the water and the very firmness and elasticity of this skin, which were such a help when the insect was on top of it, becomes a means of destruction, since now the little creature is, as it were, inclosed in an elastic sack, from which its utmost efforts frequently fail to free it. Only when the water evaporates can it use its legs and wings once more. And if the liquid is not pure water, but contains viscous impurities, it is condemned to perish. Thus we see that physical forces capable of strongly affecting the fate of small creatures, either for good or for ill, may be quite unimportant to large ones; e. g., small birds and insects may be caught by ordinary viscous materials (such as bird-lime), while it is impossible to trap mammals in this way. Through this circumstance viscous juices are tremendously important to plants by affording them protection against attacks by insects.

Of great importance, too, is the firmness of the tissues of support in both plants and animals as related to their size. If we imagine a wooden column of a given size and thickness to have its dimensions increased in the same ratio, then we must not forget that its weight, i. e., the pressure it exerts upon its base, augments according to the cube of the increase in magnitude, while the supporting power and firmness of the lower layers of the column increase only according to the square. Hence if we continue to increase the size of such a column we must finally reach a point at which the weight is too great to be supported by the lower portion of the column. If we wish to make the column stable we must increase its thickness, especially at the bottom, in a greater ratio than the height. It is at once obvious that these considerations are of the greatest importance in the kingdom of plants — in other words, the bigger a tree the thicker its trunk must be. Of course, this comparison must be confined to plants containing roughly the same proportion of woody fiber, since other things being equal, a plant with more such fiber has a greater supporting power than one with less, and may therefore have a more slender stem than the latter. If, for example, we imagine an Erika or a two-year-old sapling to be increased in size a hundred-fold, clearly such a structure would be mechanically impossible, since the stem and branches would be too slim to support the great increase in weight. The resistance to *bending* affords another interesting point of view. Let us return to our first example of the blade of grass. If it were increased a hundredfold in length and thickness, a breath of wind would break it; for when the huge mass of such a giant grass-blade lost its equilibrium ever so slightly its degree of thickness and firmness would not suffice to make it properly resistant. The weight of the upper portion of the blade, when brought out of equilibrium, increases, as we have so often seen, according to the cube, while the solidity increases only according to the square, provided, of course, that the substance of the glass blade remains the same; furthermore, since the vibratory motion of large masses tends to produce still greater forces which increase according to the fourth power of the magnitude, the case would be still more extreme.

By comparatively stronger growth in thickness the plant

compensates for these disturbances of its mechanical equilibrium. But even in this manner it cannot proceed very far, since this greater thickening of certain portions increases the weight, so that finally certain limits to growth and size are inevitably attained under the conditions involved in the solidity of the structural material — in this case, of course, wood. It is probable that the mammoth trees of California, whose trunks have diameters as great as ten yards, closely approximate these natural boundaries. But such gigantic structures are always uneconomic with respect to vital conditions, since they involve a disproportionate use of supporting and structural material, whereas life always thrives best when it follows the golden mean of neither too small nor too large, thus avoiding the difficulties and injuries to which extremes lend themselves.

I have already called attention to the fact that small plants often extend their branches horizontally. It would be mechanically impossible for such a plant to be magnified to the dimensions of a tree, since the weight of the branches increases much faster than their resistance to bending, which depends upon the transverse diameter. The same thing holds true for the effects of *traction*. If we imagine the pendant leaves of grasses to be magnified a hundredfold we at once perceive that the resistance of the leaf tissue is much too weak to bear the weight of the leaves, since this increases more rapidly than the supporting power of the transverse diameter. Thus we see that the observation we have already made in the case of animals also holds good in the kingdom of plants, namely, that the simple mechanical-physical conditions which obtain in small plants allow of an enormous variety, whereas the larger plant-structures are more limited in their range.

A meadow whose growths were increased to the size of a forest would be a monstrosity from the mechanical point of view, and I cannot better express the significance of the size of living organisms as regards their structural plan, their arrangements for securing firmness and solidity, etc., than by suggesting to the reader that he lie down in a meadow and after studying the tiniest plants therein, imagine them magnified to the size of a mighty forest.

The same law that governs plants with their structure of woody fiber holds good for the higher animals — the vertebrates with their *skeletons*.

There are the same natural limits to the size of the vertebrates, since very large ones, such as the now extinct saurians, find it difficult to move because of the weight and thickness of their bones and are not therefore perfectly viable. In the wren the bony skeleton comprises 7.1 per cent of the mass of the body; in the shrew-mouse, 7.9 per cent; in the goose, 13.4 per cent; in the dog, 14.0 per cent; in man, 17 to 18.0 per cent. Thus we see that life is governed by the materials and conditions it works with — like a sculptor, it achieves its highest perfection when substance and form are most perfectly adapted to each other.

The Lines of the Spectrum*

Their Relation to Modern Theories of Physics

By P. Zeeman

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WE omit the first portion of this article since it consists largely of a historical résumé of the work done by the late Augusto Righi and his predecessors in the field of spectroscopy with which most of our readers are, of course, more or less familiar. The latter part of the article, however, is of value in showing the most recent developments in this field and its bearing upon present day physical research.—EDITOR.

That which we term at the present day the science of spectroscopy was in the beginning merely a form of chemical analysis, known as spectrum analysis. But the great delicacy of the details revealed to us by the spectroscope and the precise measurement which this apparatus enables us to make, have given us a means of advancing our knowledge to a much greater extent than was dreamed of by Kirchhoff and Bunsen; and now-a-days the art of spectroscopy has become at once the most delicate and the most potent of the methods at our disposal for the study of the properties of atoms and of molecules.

In studying the spectra of the various elements it has been remarked that the spectral rays are frequently arranged in a very regular manner. This arrangement is simplest of all in the case of hydrogen. Balmer succeeded in establishing a simple formula which enables us to indicate with great precision the locations of the rays in the spectrum. . . . Somewhat later other physicists propounded formulas for a large number of elements, all of which were likewise comparatively simple.

In 1896 I was able to prove by making use of a Rowland space lattice that *under the influence of a powerful magnet a source of light emits a different spectrum*. In the simplest case of all each ray of the spectrum is decomposed into two or three components. We observe moreover that the rays do not emit natural light, but on the contrary, the simplest form of light known to us namely, polarized light, whose direction of vibration depends in a very simple manner upon the direction in which the magnetic force is exerted. All of this except the magnitude of the effect produced Lorentz was able to predict by taking as a starting point his theory with respect to optical and electrical phenomena—a theory which was brilliantly confirmed by later experiments. Lorentz's theory assumes that there exists in each atom a vibrating electrified particle, *i.e.*, an electron, which is the cause of the emission of light. The magnetic field is capable of influencing the movement of the electron and modifying the emission of light. It has been possible to deduce by means of experiment the fact that the vibrant particles are negatively charged, and the measurement of the distances between the components of the triple line has taught us the ratio between the charge and the mass of the particle. This same ratio was likewise found by means of the celebrated experiments made by J. J. Thomson and Leonard in the case of those electrons whose projection constitutes the cathodic rays in a tube containing a rarefied gas. The mass of the electrons is equal to 1/1840 of that of an atom of hydrogen.

It is a remarkable circumstance that all the rays in the same spectral series are decomposed in the same manner. Everyone who observes this decomposition of spectral rays finds it a very charming spectacle. At times this decomposition is much less simple. But every observer can but feel that there exists within the atom a marvelous regularity with respect to the movement of the electron, and that this regularity is capable of manifesting itself when it is modified by the magnetic force.

While a magnetic field decomposes all the rays of all the elements and while the magnitude of this effect varies very little as respects the different elements, there is one effect produced which varies considerably; let us examine this.

The question as to whether an *electric force* also exerts an influence upon the movement of the electron in an atom emitting light, was answered in the affirmative by the admirable

*Translated for the *Scientific American Monthly* from *Scientia*.

discoveries made by J. Stark at Aix-la-Chapelle in 1913—the discovery of the electrical decomposition of spectral rays. The greatest difficulty met with in investigating an electrical spectral effect resides in the application of field. Luminous gases act as conductors and as a result of this an electrical field almost immediately disappears. However, by making use of tubes containing rarefied gases in which the rays termed "canals" emit light and in which the conductivity of electricity is feeble, Stark was able to apply very intense electrical fields within a very small amount of space. The rays of hydrogen, of helium, and of lithium were the first ones which he examined. But it is very remarkable that the *diffused* rays of a spectrum are strongly influenced, while the clearly defined rays are but slightly affected. The case is here very different from that of *magnetic* decomposition, in which the rays are not separated from each other as regards the point of view of the degree of their decomposition. There is, in fact, a difference in every detail between electrical decomposition and magnetic decomposition; the only analogy that exists between them consists in the fact that polarized vibrations are obtained in both cases.

The existence of spectral series and the phenomena of magnetic and of electrical decomposition of the spectral rays, have revealed to us one of the most important mysteries in the realm of natural science.

Let us now consider for a few moments the highly promising attempts that have been made to discover the key to this mystery by the formulation of a hypothesis concerning the constitution of the atom.

Rutherford has established a theory respecting the constitution of the atom which is based upon a very large number of experimental data. According to this theory atoms consist of a positive nucleus having a positive charge surrounded by negative electrons which are attracted by this nucleus. There are excellent reasons for supposing that this positive nucleus is very small and contains, so to speak, practically the entire mass of the atom. The electrons are the ordinary electrons of which we have already spoken and their diameter is 1/40,000 part of that of an atom of hydrogen. In the solar system the diameter of the earth is 1/20,000 part of the diameter of its orbit around the sun. If, therefore, we let the earth represent an electron then an atom is a sphere having a sun as a center and a radius equal to double the distance of the earth from the sun. The electrons in the atom revolve around the nucleus; from many points of view, therefore, an atom is comparable to a planetary system.

By applying to the movement of the electron, which revolves within the atom as imagined by Rutherford, Planck's theory of *quanta* Bohr has succeeded in evolving a very simple explanation of series of spectra.

Bohr's Theory.—According to Bohr's theory an electron may revolve within an atom of hydrogen around the positive nucleus in circles, *but only in circles having definite radii.*

An emission of light occurs when the mobile electron "jumps." for reasons as yet unknown to us, from one of these definite circles to another. So long as the electron is revolving in the same circle there is no emission of light. The point last mentioned is a very bold assertion, which is in conflict with classical theories of electrodynamics, and even a few years ago a candidate for a doctor's degree in physical and mathematical sciences would have been very rash to state such a belief, which might have cost him dear at the hands of the Board of Examiners. And yet by means of these hypotheses Bohr has found an explanation both for the stability of the atomic model and for the fineness of the spectral rays emitted. The beauty of Bohr's theory resides in the first place, in the fact that not only does it explain the general laws which control the series of spectra, but it also enables us to make an exact calculation, taking as a starting point other physical magnitudes, of a constant which is found in the formulæ of spectra and whose significance we should otherwise be unable to comprehend. Furthermore, this theory enabled Bohr to make the prediction that there must exist within the spectrum of hydrogen a series in the ultra-violet, and as a matter of fact such a series was later discovered by Lyman.

According to Bohr there is within luminescent helium an electron which revolves around a nucleus having a mass which is four times that of the nucleus of hydrogen and a charge twice as great as that of the hydrogen nucleus. While the mass of the electron is negligible with respect to that of the nucleus, the characteristic number in the spectral series is *four times as great for helium as for hydrogen.* It is true, to be sure, that the nucleus is itself not entirely motionless, but it merely describes a small circle around the common center of gravity of the nucleus and of the electron. If we take this circumstance into account then the number 4 must be replaced by 4.001635; and as a matter of fact the spectroscopic observations made by Fowler had yielded the number 4.001632—which agrees quite magnificently with the theoretic figures.

Planck's Theory Concerning Quanta.—The theory of the spectral rays will always be connected with the name of Bohr and every portion of this theory which is capable of being represented by entire numbers at once recalls to our minds the name of Planck and his theory of quanta.

Sommerfeld's Theory.—A new development of Balmer's theory of the series which is in conformity with the atomic model of the Rutherford-Bohr type was suggested by Sommerfeld. Whereas Bohr assumes that the orbits of electrons are circular alone in form, Sommerfeld extends the application of the theory by assuming the existence of non-circular orbits—of *elliptical* orbits in the case of hydrogen. But what strikes us as still more beautiful in this idea is that, taking as a starting point the formulas upon which the theory of relativity is based, *i.e.*, taking into account the variation of the mass of the electrons with their velocity, Sommerfeld has succeeded in furnishing an explanation of the details of the structure which is exhibited by a great many spectral rays. The introduction of the mechanism of the theory of relativity into these questions is made necessary by the fact that the velocities of the electrons in the atom are not very small in relation to the velocity of light.

The study of the fine structure of hydrogen rays and other similar rays has enabled us to subject Sommerfeld's theory to the control of experiment. Such a control experiment may be made indirectly by means of an observation of the effect discovered by Stark, *i.e.*, of the electrical decomposition of spectral rays under the action of an electrical field, when the electron is moving, therefore, at one and the same time under the influence of the nucleus charged with electricity and under that of an external field. Einstein has developed a theory of this phenomenon and has deduced a formula of electrical decomposition which contains only known magnitudes. The accord found between this formula and experimental results is very striking, and this forms a new proof of the correctness of the model of the atom suggested by Bohr.

Paschen's Researches on the Spectrum of Helium.—But a direct confirmation of Sommerfeld's theory has been furnished by the extremely precise and careful researches made by Paschen with respect to the spectrum of luminous helium. By producing a powerful electrical discharge in a tube containing helium together with a trace of hydrogen, Fowler found a series of rays which, according to the formulas proposed by Bohr, belong to helium and not to hydrogen, as had been first supposed. All these rays discovered by Fowler have been subjected by Paschen to an extremely minute spectroscopic analysis. Thanks to the collaboration of Paschen and Sommerfeld it has been found possible to interpret fully the experimental results. By means of measurements made upon the photographs obtained by Paschen it has been found possible to confirm Sommerfeld's theory down to its smallest details.

SUMMARY

To sum the matter up, Bohr's theory regarding spectra lent peculiarly great probability to the Rutherford-Bohr model of

the atom. It must be confessed, of course, that the theory still presents great obstacles. The essential difficulties encountered reside in the fact that it is necessary to assume, as does Bohr, that an electron revolving constantly in the same orbit does not emit any radiation, and it is also necessary to accept the ideas upon which the theory of quanta is based. Within the same theory, therefore, we have combined the old principles of mechanics and of electrodynamics which have long been proven and the new hypotheses which contradict the former. Apropos of this let me cite the words uttered by Poincaré in 1911 before the Solvay Council: "We must not forget that there is no proposition which cannot be readily demonstrated provided that we employ two contradictory premises in making our demonstration."

The three great theories of modern physics—the theory of electrons, the theory of quanta, and the theory of relativity, have been decisive factors in enabling us to comprehend the harmony of the phenomena afforded us by spectral rays. The great mathematician whom we have just mentioned would certainly have accepted, could he have been acquainted with them, the physical theories upon which Bohr's model of the atom is based, now that it has been proved possible to connect with each other a multitude of data by means of them and, above all, since these theories have enabled us to make predictions which have been later fulfilled.

ASTON'S METHOD OF MASS SPECTROSCOPY

Of extremely recent date are the thorough-going experiments made by the English physicist, Aston, with respect to the character of certain chemical elements. He has proved that a number of these at least, instead of being single elements as has been hitherto supposed, consist of isotopic mixtures. His method is purely physical in nature, since chemical methods would be unavailing to separate mixtures of this character, but, as a result of the difference in atomic weights there are certain differences in the influence exerted by an electric and magnetic field. This has enabled Aston to work out the details of the process by means of which isotopic mixtures can be recognized as such and the atomic weights of their constituents determined. Chlorine has always been one of the best known examples of deviation from Prout's hypothesis. This long-known chemical element has an atomic weight of 35.46; it is, therefore, not an exact multiple of hydrogen, but Aston has recently proved by his method of the "spectroscopy of masses" that chlorine consists of two isotopes having respective atomic weights of 35 and 37. Previous to this he was able to prove that the noble gas neon which has an atomic weight of 20.2, represents a mixture of two elements, called by him neon and meta-neon, whose atomic weights are again exact multiples of hydrogen—namely, 20 and 22. It is evident in this case that the isotopic mixture is not half and half in its proportions but that about 90 per cent of it consists of neon (20) while there is only about 10 per cent of the metaneon (22).

In the course of the last few months Aston has succeeded in demonstrating that an entire series of chemical elements must really be regarded as isotopic mixtures and his experiments are still far from being concluded. We may mention the instances of bromine, of the noble gases, krypton and xenon, and of quicksilver; the latter consists presumably of a whole series of isotopes—five or more perhaps—whose atomic weights gradually increase from 197 to 204; the mixture of these produces the ordinarily given value of the atomic weight of mercury, 200.6.

These experiments whose deep significance with regard to chemistry in general cannot be denied, throw a new light upon the ancient hypothesis of Prout, and in the immediate future they will probably solve the problem as to whether we really may regard hydrogen as the basic element from which all others have been derived.

Thus we see how truly tremendous are the consequences which have followed upon the apparently trivial discovery some 25 years ago, of the radioactivity of uranium. Our concepts as to the very nature of the chemical elements have undergone a fundamental alteration. In the phenomena of the radioactive disintegration processes, we may observe the gradual breaking down of elements having a high atomic weight into those having a low atomic weight. And in these most recent investigations with respect to the isotopy of the ordinary chemical elements, we may perhaps find a proof of the upbuilding of the entire world of matter from a single primeval element—hydrogen.

EFFECT OF ULTRAVIOLET RAYS UPON THE EGGS OF THE SEA URCHIN

Those cytologists who undertake to study the respective parts played in the living cell by the nucleus and cytoplasm through the method of eliminating first one and then the other are beset by great technical difficulties because of the infinitesimal size of the elements of the cell. A recent investigator, M. Tchahotine, has invented a contrivance which enables him to direct upon a given point of the cell, for instance upon the nucleus, a beam of U.V. rays of extreme fineness (down to about 1 micron in diameter). The nuclear substances absorb these rays with more intensity than does the cytoplasm, and because of this fact the experimenter hoped to find himself able to exert upon the nucleus a localized and elective action, by means of an irradiation of very brief extent. However, in spite of the brevity of the operation he found that the cytoplasm was attacked by the passage of the rays to almost as great an extent as was the nucleus. When we study the mechanism of the manner in which the U.V. rays act upon the eggs of the sea urchin, we find that it is the plasmatic layer of the periphery which is chiefly sensitive, and which sets in motion the process of cytolysis. M. Tchahotine concluded, therefore, that it was necessary to find a means of rendering this layer less sensitive, in other words of *stabilizing* it during a length of time sufficient to produce a lesion of the nucleus. The results of his experiments are recounted in the *C. R. Soc. de Biologie* (Paris) for Dec. 1920. We take the following résumé from the *Revue Scientifique* (Paris) for March 1921:

The researches made by J. Loeb and R. Lillie upon the part played by various ions in the variations in the permeability of the cell have shown that while the permeability is augmented by the ions potassium and sodium, the ion calcium is antagonistic to them: it solidifies and renders less permeable the superficial stratum of the cell. M. Tchahotine conceived the idea of keeping the eggs, in order to irradiate them, in the solutions of these various ions. He first showed that sea-urchin eggs irradiated for 3 min. *in toto*, in sea water, succumbed at the end of 6 or 8 min. In a solution of potassium chloride or sodium chloride, they succumbed after the lapse of only 1 or 2 minutes. But they resisted as long as 50 min. in a solution of calcium chloride, and even for several hours if instead of using pure calcium chloride, which is always injurious, this was mixed with sea-water.

In order to act upon the nucleus alone, M. Tchahotine keeps the sea-urchin egg in a solution containing, per cc. of sea-water, 10 drops of calcium chloride; he compresses and flattens it in a minute tube of collodion, which diminishes the thickness of the layer of plasma between the nucleus and the surface of the cell, and he directs upon the nucleus a beam of U.V. rays during a period of 1 to 2 min. If this microscopic "radio-puncture" takes place at the instant when the egg is in the stage of 2 blastomeres, the evolution of the blastomere with the nucleus, which has suffered a lesion, is at once arrested, while the other continues to divide normally.

Barks with a Bite

Some of the Trees and Shrubs Whose Cortices Contribute to the Medicine Bottle

ONE of the pleasures which a small bōy finds in roaming through the woods is the tasting of the various twigs which tempt him by their attractive odor or aspect. Thus he comes to know trees and shrubs not only by the look of leaf and bark and flower, but by the taste of the bark as well as of the fruit. This is exactly what was done by those earliest Boy Scouts, our primeval ancestors, and in this way they learned gradually that the aromatic or bitter flavors found in the bark of many plants indicate valuable medicinal properties, while others have a piquancy which made them prized as condiments. At the present time there is an enormous trade in various kinds of barks for the sake of the therapeutic value of their essential principles. While the retail drug stores still have various kinds of bark for sale from which infusions can be made at home, the great bulk of the trade is between the producer and the wholesale manufacturer who extracts the valuable principle and puts it on the market in the more convenient if more expensive forms of a prepared tincture, pill, powder, or tablet.

The United States Pharmacopœia lists 17 kinds of bark used in medicine, and no less than 12 of these are found in the United States. There are, in fact, no less than 35 kinds of bark altogether grown in this country, which are more or less widely used for preparing simple home-made remedies, although only 17 are classed as "official."

These barks fall into various classes according to their properties. Some are valued, for example, as febrifuges, chief of which, of course, is the Peruvian bark or cinchona, to which the world owes the priceless boon of quinine. A second class includes those which exert a cathartic or laxative effect and of these the most highly prized is the bark of the graceful little buckthorn tree found in northern California, and known by its Spanish name of Cascara Sagrada (sacred bark). A third class includes those which stimulate the flow of one or another of the secretions of the body, such as the saliva, gastric juice, perspiration, mucus, etc. Others are soothing in nature, such as an infusion of slippery elm, and may be used either externally in the form of poultices or for preparing soothing draughts in cases of sore throats, etc. Still others are said somewhat vaguely to possess "tonic" properties.

The various active principles found in the rind of plants are products of the vital activities of the plant, and are usually to be regarded as virtually excretions, *i.e.*, as substances which would be injurious to the life of the plant if they remained within its active tissues and which are, therefore, stored up in some convenient place, such as the bark, where they will, at least, do no harm and may, in many cases, be of actual service to the plant by protecting it from the enemies which might destroy it were they not deterred by the bitter or poisonous substances they meet with in bark, leaves, or fruit.

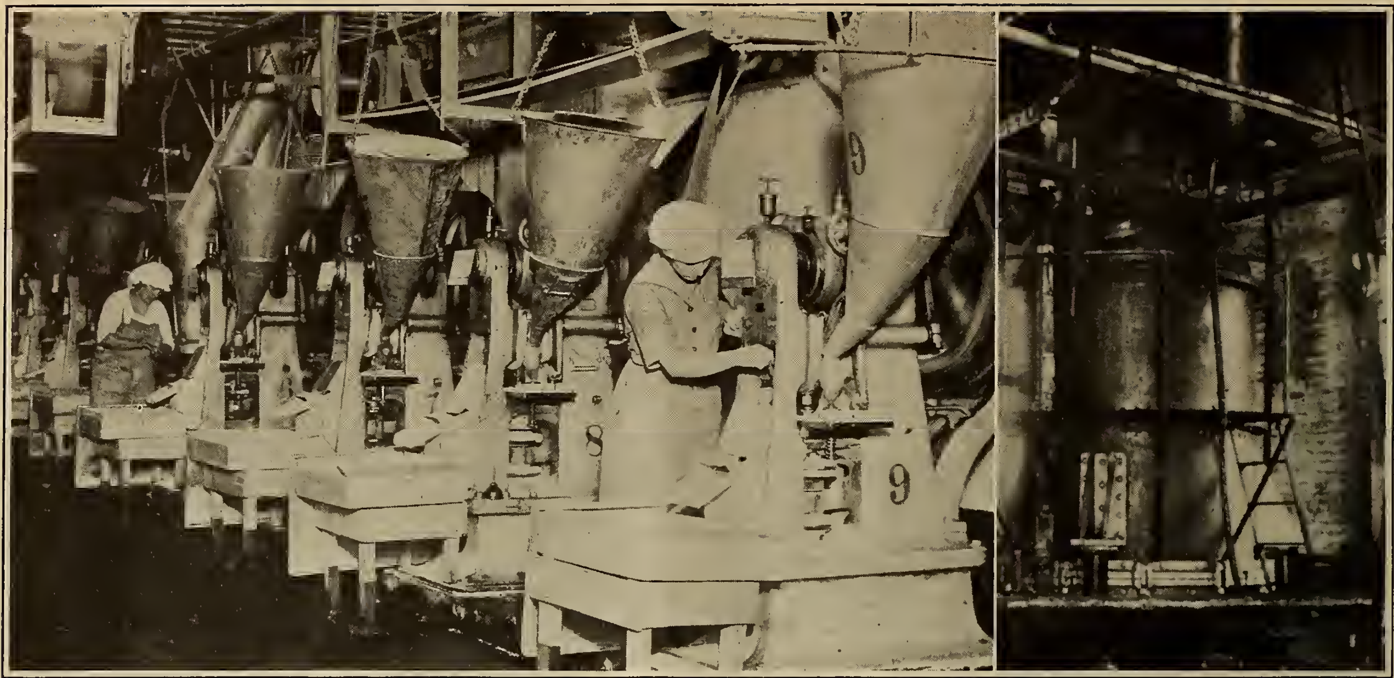
There are various ways of collecting bark and the matter is one of considerable importance, since by a wrong method it is easy to flay the tree alive, so to speak. This killing of the goose that lays the golden egg has been, and still is, all too common a folly in the United States. Except where very young twigs or shoots are used the outer corky layer is first shaved off before the bark is peeled, and this process is called "rossing." Then incisions a few inches wide are made, and strips of various lengths depending upon the nature of the bark are peeled off. Sometimes a long incision is made lengthwise in the bark of a branch or root and the bark is slipped off. In some cases it comes off readily, while in others it must first be pounded with a mallet to loosen it.

PERUVIAN BARK

This is a bark obtained from several trees belonging to the genus *Cinchona*, which grows spontaneously in many parts of South America, but more particularly in Peru. The tree somewhat resembles a cherry tree in appearance, and has white or pink flowers. This valuable medicine was formerly called Jesuit's Bark, from having been introduced into Europe by the members of that order settled in South America. They were instructed in its use by the natives of Peru, and it continued for many years a source of profit to the Order. Its botanical name given it by Linnaeus was derived from that of the Countess del Chincon, the lady of a Spanish viceroy, who had been cured by it. The tree from which it is obtained grows abundantly in the forests of Quito and Peru, and the bark is cut by the natives in the months of September, October, and November, during which alone the weather is free

CINCHONA OFFICINALIS *CASCARA SAGRADA* *PRUNUS SEROTINA*, THE WILD CHERRY

General appearance and botanical details of three principal medicinal-bark trees



EXAMPLES OF THE MACHINERY USED TO EXTRACT THE BITE FROM THE BARK AND MAKE IT AVAILABLE FOR OUR USE
Left: Still for producing fluid extract of cascara. *Right:* A battery of tablet machines, which in a year turn out fifteen tablets for each person in the United States

from rain. The bark is of three kinds—red, yellow and pale, of which the yellow and pale barks are considered the best since the active principle is stronger. The most valuable quality of all is of a pale reddish yellow tint; material possessing the color is called crown-bark. This is the original Peruvian bark. The yellow bark grows in Bolivia as well as in Peru while the red comes mostly from Ecuador.

QUININE

Quinine or quinia is a drug ($C_{20}H_{24}N_2O_2$) largely used in the cure of malarial fevers, in which it is regarded as a specific. It is also a valuable tonic. Quinine is one of the five most important of the 21 alkaloids obtained from the bark of the cinchona tree (Peruvian bark), the others being quinidine, cinchonidine, cinchonine and hydroquinine. The curative power of these alkaloids is accurately shown by the report, dated April, 1868, of a commission appointed by the British Indian government (Madras) after the suggestion of Clements R. Markham, C.B., F.R.S. Cases of fever numbering 2472 were treated, and the results showed failures per 1000 as follows: Quinidine, 5; quinine, 7; cinchonidine, 10; cinchonine, 23. Quinine alkaloid is seldom used, as it is very insoluble. The salt known as quinine sulfate is generally used but the acid hydrochloride (also called the "chlorate") is preferred by some careful physicians, and for children and the more susceptible the tannate is generally prescribed, in doses two or three times as large.

The average dose of quinine sulfate for adults in the United States is four to five grains every three or four hours beginning a few hours after a paroxysm and continuing until three hours before another is due, when a much larger dose is given. If, as is to be expected, no paroxysm occurs, the treatment is renewed for some hours on the second day, and then again on the ninth day, which completes the cure. In warmer and more fever-ridden countries, twice to three times this amount is given. Quinine is also used with great success as a prophylactic. Since 1902 it has been distributed free by the Italian government in the malarial sections. The preventive amount for adults is five to seven grains of the sulfate per day divided into two doses. Children receive two or three grains daily during the malarial season. As a tonic the best results are obtained by doses of one-half grain of the hydrochloride twice daily. In the administration of quinine it has been repeatedly noticed that toxic symptoms have been developed in some cases; and investigations have shown that in certain conditions both cinchonine and quinine develop poisonous isomeric forms, known as cinchotoxine and quinotoxine. This change takes place in the preparation of quinine when the drying heat (see below) is prolonged and acetic acid is present. The same changes have been noted at the temperature of the body in the presence of such acids as are sometimes found in the digestive tract, particularly acetic and citric acids. The poisonous symptoms are sometimes severe, and patients developing them should be treated with quinidine. The average consumption of quinine sulfate in the world is 15,000,000 ounces a year, and the approximate average net cost of production is 18 cents per ounce. The importations into the United States in the fiscal year ended June 30, 1918, were 3,273,628 pounds of cinchona and other quinine-yielding barks, valued at $810,775, and capable of supplying an average of 4 per cent (2,095,122 ounces) of quinine sulfate; and 1,445,702 ounces of quinine sulfate and other alkaloids and salts of cinchona bark, valued at $656,945.

To manufacture quinine the bark is ground to a powder that will sift through screens of 70 meshes to the inch, and mixed with one-third its weight of slaked lime, made into a paste with water and dried thoroughly at the boiling temperature of water. It is then powdered and mixed with petroleum and boiled about five hours, the alkaloids in the bark dissolving in the oil, or amyl alcohol may be used for the solvent. The powder is then allowed to settle, and the oil is drawn off and agitated with hydrochloric acid. The alkaloids in mixture, known commercially as quinidine, now leave the oil and go to the acid water, in which they are more soluble than in the oil. The oil and water separate upon standing, and the acid water is drawn off and neutralized with an excess of ammonia or soda, whereupon the quinine and other alkaloids are precipitated together. The alkaloids are redissolved in very dilute sulfuric acid and then the solution is almost but not quite neutralized by very dilute soda solution cautiously added. It is then heated to the boiling point and enough boiling water added to make 70 ounces of water for each ounce of mixed alkaloids. When the solution cools the quinine sulfate crystallizes out from the mother liquor which retains the other algaloids including quinidine from the mother liquor. The quinine thus obtained is purified by fractional crystallization.

Until about 1850 quinine was obtained only from South American cinchona bark. By that time it was in such world-wide demand that the price had risen to about $20 an ounce.

For this reason experiments were made by the Dutch in Java and the British in India to grow the tree. The conditions in Dutch Java were found to resemble closely those in its native habitat, where it is found to succeed best in an equable tropical temperature, at an altitude of from 5000 to 7000 feet, on a volcanic soil and with a rainfall of from 100 to 200 inches of rain per year. It is said, indeed, that these transplanted trees are now rather more vigorous than their forebears from Peru, because of the improved methods of cultivation discovered by Dutch agriculturists. The annual average export from Java is estimated (1918) at 16,500,000 pounds of bark, some of which yields as high as 10 per cent quinine while an average of 2 to 5 per cent is considered fair from the Peruvian bark.

CASCARA SAGRADA

Perhaps the most important of the barks native to the United States is the one known variously as chittembark, sacred bark (a translation of the Spanish name of the subhead above), bearberry tree, bearwood, shittim wood, Purshiana bark and Persian's bark. The pharmacopecial name is Rhamns purshiana. The tree occurs on the sides and bottoms of the cañons from the Rocky Mountains to the Pacific coast, extending north into British Columbia. It is of small size, usually from fifteen to twenty feet in height, the young twigs being hairy and the leaves rather thin. It belongs to the buckthorn family (*Rhamnaceæ*). The dark green leaves are elliptical in form, from two to six inches long, and about one to three inches wide, blunt at the apex or with a short sharp point, finely saw-toothed, rounded or slightly heart-shaped at the base, somewhat hairy on the lower surface, and rather prominently veined. The rather small, insignificant greenish flowers are produced in umbels, or clusters, and are followed by black, ovoid, 3-seeded berries, of a somewhat insipid taste.

The cascara sagrada of commerce occurs in curved or quilled pieces, the outer surface of which is reddish brown, and usually covered with growths of light-colored or grayish lichen, wrinkled and somewhat fissured. The inner surface of the bark is smooth and marked with very fine lines; at first the inside is yellowish, but with age it turns a dark brown color. The whole breaks with a short, sharp, yellowish fracture, and has a somewhat aromatic odor and an exceedingly bitter taste. The saliva is colored yellow by it, and anything with which the bark comes in contact for any length of time will also be stained yellow. Cascara sagrada is official in the United States Pharmacopœia.

The collecting season for cascara opens about the end of May or early in June and closes about the end of August, just before the rainy season sets in, as bark collected after exposure to wet weather is difficult to cure properly. After the strips of bark have been removed from the trees they are generally strung on wires to dry, care being taken not to expose the inner surface to the sun, the object being to retain the yellow color, as the action of the sunlight tends to darken the color, an undesirable result, inasmuch as it lowers the market price. During the drying process the strips curl up, forming quills; when sufficiently dried these are cut or broken up into smaller pieces.

Several years are generally required after collection to age the bark properly for medicinal purposes, and the United States Pharmacopœia directs that it should not be used until at least one year after it has been gathered. Some crude-drug dealers undertake the "aging" of the bark themselves rather than leave it to collectors.

Many trees are annually destroyed in the collection of cascara sagrada, as they are usually peeled to such an extent that no new bark is formed. It has been estimated that one tree furnishes approximately ten pounds of bark, and granting a crop of 1,000,000 pounds a year, 100,000 trees are thus annually destroyed, and the world's consumption is said to be about 2,000,000 pounds a year. On account of the fact that cascara sagrada requires several years' aging before use, a shortage in the crop is not immediately felt. Cascara sagrada is a most valuable laxative, differing from other drugs of this character in that it tones up the entire intestinal tract, making long-continued and gradually increasing dosage unnecessary.

THE WILD CHERRY

This species is known to the naturalist as *Prunus secretina*, and to the pharmaceutist as *Prunus virginiana*. Its common names include wild black cherry, cabinet cherry, black choke, rum cherry, whiskey cherry, and Virginian prune-bark. It occurs in woods or open places, and is most abundant in the Southeastern States, but its range extends from Nova Scotia to Florida, westward to Texas, and north through Indian Territory, the eastern portion of Kansas, Nebraska, and South Dakota.

The elongated, drooping, pretty clusters of white flowers of the wild cherry are usually produced in May. The tree sometimes reaches a height of 90 feet, and a maximum trunk diameter of 4 feet. The trunk is straight and covered with a rough black bark; the young branches, however, are smooth and reddish. The reddish brown wood of the wild cherry

SASSAFRAS SLIPPERY ELM WITCH HAZEL

Three more familiar medicinal members of the vegetable kingdom, best known under their common names

is fine-grained, hard and is used in cabinet making. The outer surface of wild cherry bark is smooth and glossy, green or brownish-green in color and marked with a number of pale colored lines or grooves, known to botanists as lenticels. The inner surface is rusty looking and marked with a network of minute crevices. It breaks with a short granular fracture. The value of the bark is due to the hydrocyanic acid which it contains, and it is this which gives it its aromatic bitter taste, which much resembles that of the kernel of the peach seed, or the traditional bitter almond that figures in every prussic-acid murder story. When the bark is soaked in water, the latter acquires the same taste and odor and astringency. The bark is collected in autumn, at which time it contains the greatest amount of hydrocyanic acid. The outer bark is removed, and the green layer underneath is stripped off and dried. The young, thin bark is considered the best and brings the highest price. The infusion is considered an excellent tonic and it is also sedative. It is likewise a common ingredient in many cough mixtures.

EMOLLIENT AND AROMATIC BARKS

Chief among the barks which supply soothing or emollient are the slippery elm, beloved of every boy who roams the woods and the witch-hazel. The commercial article consists of pale brown or whitish brown flat pieces tied in bundles, and it also occurs on the market in smaller pieces of uneven size, suitable for grinding purposes, but which brings a lower price. The flat pieces are of varying length and width, about an eighth of an inch in thickness, the outer bark having been removed in accordance with the requirements of the pharmacopœia, but sometimes patches of it are still found adhering. The flat pieces are tough and break with a fibrous fracture. The inner surface is yellowish brown and marked with fine furrows. Slippery elm has a faint peculiar odor and a mucilaginous but insipid taste. The mucilaginous character of slippery elm bark renders it useful in relieving coughs, and it is also employed in treating diarrheal complaints. It is soothing and allays inflammation and is also somewhat nutritious. In certain sections of the country poultices are made from the bark and applied to abscesses.

By witch-hazel or hamamelis bark, official in the United States Pharmacopœia, is understood the bark and the twigs of the witch-hazel. The bark is found in commerce in the form of quills, varying in length and width, and is sometimes a purplish brown on the outside, sometimes a whitish or grayish brown color; occasionally it is smooth with a few warty protuberances or numerous lenticels, and again it is furrowed and scaly, or even ragged. The inside is pale brown or yellowish, usually with long, straight lines. Sometimes fragments of the whitish wood are found adhering to the inner surface, and such bark should be discarded. Witch-hazel bark breaks with a weak fracture. There is a scarcely perceptible odor, and the taste is astringent and somewhat bitter. The tough, flexible twigs do not exceed one-quarter of an inch in diameter, are branching, yellowish brown to a very dark or purplish brown, faintly wrinkled lengthwise, and with small, round, light-colored lenticels. There is a small central pith, and the bark which surrounds the greenish white wood occupies about one-fifth of the radius. If the twigs are more than a quarter of an inch in thickness, there will be too large a percentage of wood, which is without medical value. Witch-hazel is used for relieving inflammation of various kinds and its soothing properties were known to the American Indians. The name "witch-hazel" is derived from the fact that formerly the forked branches were used as "divining rods," it having been the belief that these branches were endowed with a miraculous power of locating treasures, sources of water for wells, etc.

Among the aromatic barks we may mention that of the white pine, used in making cough syrup; the tamarack or larch, used as a laxative and diuretic; the bayberry, used as a tonic and astringent; the sweet birch, the magnolia (known also as cucumber tree, sweet bay, swamp laurel, umbrella tree, elk wood, etc.) which has a warm, spicy and slightly bitter and astringent taste, and which is used as a tonic and for exciting perspiration; and the sassafras, a favorite source of the domestic tonic or "spring tea."

Other barks which are less well known, but have been used variously as tonics, astringents, diuretics, expectorants, etc., are those of the cascarilla tulip, poplar, the fringe tree, the white willow, the aspen, the butternut, the white oak, the blackberry, the American mountain ash, the prickly ash, the wafer ash, the black alder, the horse chestnut, the dog wood, the moose wood, the cramped bark tree, the black haw, the bitter and astringent taste, and which is used as a tonic and

PREVENTING CORROSION IN IRON AND STEEL UNDER WATER

F. N. Speller presented a paper under this title at the April meeting of the American Electro Chemical Society and included a summary of results on the corrosion of wrought iron and steel in hot water supply systems from a number of investigations. It appears from the work of the author and others that the intensity of corrosion under water is approximately proportional to the amount of oxygen in the water. If water pipes are to be protected from internal corrosion, say, at 180 deg. fahr., as in a heating system, it is not necescary to have the oxygen content lower than 0.4 cc. per liter. If steam boilers, superheaters and economizers operating at a higher temperature are to be protected the oxygen content must be less than 0.2 cc. per liter. Cold water, varying with the season of the year and temperature of the water, carries from 5 to 10 cc. of oxygen per liter. There are two systems by which the free oxygen may be removed.

The mechanical de-areating method consists in either spraying water into a high vacuum chamber with temperature and pressure control to remove the gases or the water may be passed over baffles under the same conditions. The air and vapor are drawn through a condenser which accompanies a transfer of heat to the incoming cold water and while the plant is necessarily expensive the results are satisfactory.

The fixing of the free oxygen by chemical combination amounts to so satisfying the oxygen with iron before it enters the heating system as to prevent attack upon the pipes. The heated water is, therefore, passed into a storage tank in which are placed a large number of expanded sheet iron plates calculated to afford from 60 to 70 square feet per cu. ft. of space. In half an hour at 170 deg. fahr. oxygen is reduced in this way to about 0.3 cc. per liter. Even when this treatment increases the carbon dioxide practically no after corrosion is experienced. Where water treated in this way is used for domestic purposes it is usually advisable to filter it.

In power plants satisfactory and economical de-aeration is obtained when open-feed water heaters operating at 180 deg. fahr. have their water space filled with thin steel lathing or if the water is caused to flow from the open heaters to a second tank containing steel scrap in this form. The open heater can be made to reduce the free oxygen from 8 cc. to 2 cc. per liter and the residual oxygen is rapidly fixed in the presence of the scrap steel. Water after such treatment is inactive toward iron and may be used without corrosion.

In his paper Mr. Speller gives some discussion to the corrosion of non-ferrous metals and says regarding the rate of corrosion that this "may be retarded by increasing the proportion of hydroxyl ions with relation to the hydrogen ions present in the water. In practice, in the case of boiler water, this can be carried out by the use of 5 to 10 grams per gallon of hydroxide alkalinity but with domestic water it is possible to use only a comparatively small amount of alkali and the protection afforded is proportionately lessened." Great Lakes water with about 8 grams per gallon of calcium carbonate is very much less corrosive than New York City water with one or two grams per gallon of carbonates although each have about the same amount of oxygen.

Anaphylaxia: Its Role and Its Treatment*

A Study of Poisons that Make the Victim More Sensitive to a Second Dose

By Charles Richet

LET me recall in a few words the principle involved in the phenomenon of anaphylaxia discovered by me in 1902:

If any toxic colloidal substance, a fatal dose of which has been previously determined, be injected into the circulatory system of the body, it is found that those animals which have been capable of resisting death—*i.e.*, who have received a dose not quite sufficient to be fatal—have become so sensitive to the action of the poison in question that they will die from the effects of a new injection, even though the dose in the latter be only one-tenth as great as the original dose. Sometimes, indeed, a dose only one hundredth part as great as the dose ordinarily fatal will suffice to cause death from this second injection. This disturbance is known as the anaphylactic shock.

Thus, a special condition of hyper-sensibility in the organism has been created by the original dose. It has always been known that the state of being *accustomed to the poison*, a state often termed *mithridatism*, would enable the organism, thanks to its habituation to the poison, to support doses of increasing strength. Morphine addicts, for example, are capable of ingesting doses of morphine one hundred times as great as normal individuals can do.

From the point of view of general biology and of the defence mechanisms and organisms, we well understand that phenomenon of habituation which increases the resistance to poisons of the body. But we do not comprehend at all how this state of anaphylaxia can be useful to living creatures, since this state creates in them an actual inferiority, because of the fact that this hyper-sensibility makes them less resistant to toxic action.

And yet we can scarcely suppose that there are for living creatures conditions unfavorable to their resistance. Up to the present time all that we have learned with respect to the adaptation of living creatures to the medium in which they live, through a change in the properties of their tissues is, that the power of resistance undergoes an increase. Hence anaphylaxia in which state a diminished resistance is exhibited is a sort of biological paradox which is well worth while to examine with atteution.

It is evident that the biological utility of anaphylaxia cannot be established by experimeutal facts. Only theoretical ideas are capable of doing this, but in such a case as this hypotheses are quite legitimate when they are based upon positive experiments, aud wheu they succeed in disposiug of the siugular anomaly here iuvolved, which would be almost unique in the field of general biology, of a property belouging to living creatures which is unfavorable to the life of the individual or of the species.

It is my purpose, therefore, to present in these pages what seems to me the most rational explanatiou of the matter. But in order that the reader may better compreheud what I am about to say, it is advisable that I should enter into certain details with respect to the effect produced by and upon the poisons introduced into a living body.

There are two kinds of substances—toxic and non-toxic—which may succeed in penetrating the blood. These may be classified as *colloids* on the one hand, aud as *crystalloids* on the other.

The latter are substances which are capable of being crystallized, which are soluble and which are able to pass through membranes. Examples of these include metallic salts, sugar, urea, and alkaloids, all of which have this common property of being more or less readily diffusible. When these bodies are injected into the blood they are highly toxic in some cases and very slightly so in others. But whether they be toxic or not, whether they be as harmless as common salt or as hypertoxid as the sulphate of atropine, they are *incapable of accumulating in the blood*. This is because they are at once eliminated either by the lungs, if they are gaseous, or by the kidneys if they are soluble.

No crystalloid poison produces the phenomena of anaphylaxia.

Because of this fact we are at once led to conclude that these poisons fail to exert an anaphylactic effect because they are incapable of accumulating in the blood. And we are further led to formulate the following law which forms the expression of a very general fact:

Poisons which do not accumulate in the blood do not cause anaphylaxia.

If there is habituation in certain cases even though we do not clearly grasp the mechanism by which the body has thus become accustomed to the substance in question, it is because all living cells have this power of supporting stronger and stronger doses of any given poison. I have succeeded in accustoming the lactic ferment to live in solutious of thallium nitrate, of sodium arseniate or of potassium bromide, five times as strong as the solutions ordinarily compatible with the life of the organisms which compose the normal lactic ferment. Just as we see that addicts of morphine can support without dying injections of as much as two or three grams of the chloro-hydrate of morphine, so we observe that this lactic ferment, provided it has first been subjected to a process of habituation, is able to live in solutions of the nitrate of thallium, which are eight times as strong as the solutions in which non-habituated lactic ferment can exist.

But at any rate among the higher vertibrates, if there be habituation there is no accumulation because of the fact that the ingested morphine is elimiuated by the kidueys.

NON-ELIMINATION OF COLLOIDS

But it has been proved by definite experiment that inorder crystalloids, colloids fail to be eliminated. Colloids have properties very different from those of crystalloids: they cannot be crystallized and they do not pass through membranes and as a result they cannot be eliminated from the body. Hence the reaction exhibited by the organism, *i.e.*, the resistance to colloid poisons shown by the body, must be according to entirely different methods.

Wheu a concentrated solution of chloride of sodium is ejected into the body, the latter at once begius to defend itself against this substance which has become toxic through being preseut in excess by a very simple process, namely: by elimination through the kidneys. After the injection of 20 grams of common salt this excess is eliminated withiu the space of an hour at most, and the blood is found to have returned to the *statu quo ante*. But when the toxic substance in questiou is a colloid, elimination by means of the kidneys becomes impossible and the poisonous material cannot be eliminated either through the kidneys or the lungs.

But it has been proved by definite experiment that in order to rid itself of a poison which it is incapable of excreting the organism proceeds, by a truly marvelous adaptation, to manufacture a counter-poison, *i.e.*, an *anti-toxin*. This was proved by Behring in 1892, when he repeated the experiments made by me in 1887 with respect to sero-therapy. He discovered what I did not perceive in 1887, that there is a production of anti-toxius (diphtheric and tetanic) after the toxins of diph-

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theria or tetanus have been injected. I had showed in 1887 that the blood possesses an anti-toxic potency, but I had not been able to detect the cause of this power; this was accomplished four years later by Behring.

It ensues that after the injection of the toxic substance a state of *immunity* is produced in certain cases, *i.e.*, the body exhibits an increased resistance to the poison. This is the general method of defense against the ingestion of a colloidal poison.

THE CAUSE OF ANAPHYLAXIA

But in order to explain the phenomena of anaphylaxia we must have recourse to another idea: we must assume that there appears in the blood another substance whose function it is to reinforce the poison. I have not been able to isolate this substance, but I have given it the name of *toxogenin* (it is termed also *anaphylotoxin* by Friedberger and sensibilimogen by Besredka).

Hence we see that the organism possesses two methods of defense against penetration by colloids and by toxins: it produces *anti-toxins* on the one hand, and a *toxogenin* on the other.

Why, then, from the *finalist* point of view with which we are here concerned, is a toxogenin produced, *i.e.*, a substance whose office is to reinforce the deleterious effects of the poison? for, when an animal has been anaphylactised, even a small dose of the toxin—sometimes only a hundredth part of the usual fatal dose—overwhelmingly disastrous effects are produced. In the space of less than a minute the anaphylactised dog falls to the ground unconscious, with difficult respiration, with a heart beating at first tumultuously and then very feebly, and with a cessation of the circulation of the blood; with a severe congestion of the entire intestinal apparatus, with a profuse bloody diarrhœa, with violent and uncheckable vomiting, with a mental and a lamentable exhibition of agonized suffering, so that it often seems as if the animal is about to die—and, indeed, it often happens that the animal does die within a few minutes from this terrific anaphylactic shock.

The following experiment is very well fitted for the purpose of showing the degree to which anaphylaxia and immunity may co-exist and even coincide: from a Brazilian plant called the *Hura crepitans* I have extracted a toxic albumen to which I have given the name of *crepitine*. This substance possesses exceedingly curious biological properties. When administered to an animal no poisonous effect is at first apparent, but at the end of ten or fifteen days every dog in whose veins it had been injected was dead.

Assuming the toxic dose to be 1 gram (an amount which is fatal in 15 days), one-half a gram may be injected without producing any immediate effect upon the animal to all appearances; 25 grams must be injected in order to cause immediate death. After having the first amount injected the animal appeared slightly ill at the end of 15 days; but at the end of a month it had apparently returned to its original condition, although it was a little bit thin. *Thus the animal was anaphylactized and immunized at one and the same time.*

I proved this to be the case in the following manner. One month after the first injection of 0.5 gr. I injected in this dog a dose of 1 gram, which is fatal for a normal dog, but which does not kill the animal till 15 days have elapsed. Within the space of a minute the anaphylactized animal fell to the ground lying upon its side in an almost dying condition. For several minutes I was not sure, indeed, whether it would survive. It did, however, recover, being almost normal at the end of 15 days. The normal dog, on the other hand, which has received for the first time this dose of 1 gr. of crepitine shows no effect at the moment of the injection, but during the days which follow it begins to fail in health, so that it dies on the fifteenth day. The lessons to be drawn from these results are first, that *the animal was not anaphylactized*—hence no immediate effects were exhibited; and second, *it was not immunized*—hence it was not able to resist the fatal dose injected later.

FINALITY

Let us now try to interpret this experiment, keeping always in mind its relation to finalism.

It is above all important with respect to the resistance to poisons presented by living creatures, that as soon as the first sign of a given poison shows itself, a violent symptom should be exhibited, *e.g.*, by an abrupt and vigorous reaction which will prevent the continuation of the toxic action. If the organism starts to defend itself at the very beginning then the injection cannot be continued. Through anaphylaxia the organism has been put on its guard. Warned by a first intoxication the nervous system has become so sensitive that it will defend itself with vigor against a second intoxication.

But we must go still further in the direction of finality, for thus far we might suppose that the colloid injected in a dose of inoffensive amount may have remained in the organism without causing the production either of a toxogenin or of an anti-toxin. For example, when a foreign serum is injected it produces no ill-effect, provided the dose is not too strong. Thus, 2 cubic centimeters of horse serum can be injected in a small guinea pig without harmful results. But this injection of horse serum, however, occasions very intense anaphylactic effects—effects quite unexpected, since a hundredth part of a cubic centimeter of the same serum injected in the same guinea pig three weeks later will cause its instant death.

It is evident that in this case the organism was tremendously sensitized. What is the reason for this? What is the object of this extraordinary property in our tissues?

The following hypothesis appears to give an answer to these questions:

The composition of the blood has been altered through its invasion of a foreign colloid, and as a result of this the chemical constitution of the guinea pig's blood has been modified. This modification is an actual attack upon the biologico-chemical stability of the guinea pig species.

But if it be true that certain general laws govern the life of animals it is of first importance that these must persist with quite definite specific characters. In spite of all the various forces which tend to transform these, in spite of the various mediums which form their environment, they exhibit an almost irresistible tendency to remain the same in spite of all external influences. It is true that in spite of this law mutations sometimes occur, but these are produced seldom and with difficulty. A very lengthy effort is required on the part of external forces to produce in individuals modifications sufficiently stable to be transmitted to its descendants. Even if there be an occasional hereditary transmission of a mutation, there is an almost inevitable return to the normal. Nature appears to have willed it that each species should remain invariable. Everything happens as if Time had ceased to exist. The guinea pig species and the horse species, for example, must pursue their existence during a long series of identical generations.

The stability of species appears to be the law of nature.

We are justified in ascribing intent to natural forces for this opinion is the result of innumerable and incontestable observations. These are facts and it is our right to give a general application to these facts by saying that everything happens as if the stability of species was one of the definite objects of Nature.

Since this is true the introduction into the blood of foreign substances capable of remaining there without being eliminated, and which as a result of this might finally form a part of the chemical constitution of the creatures in question, forms a grave peril to the stability of the species. A guinea pig having 1 per cent of horse blood in its blood would no longer be an entirely normal guinea pig. As a result of this it is essential to the stability of the species that the accident which introduced a foreign element into the body of the guinea pig should

not be repeated. In other words, this 1 per cent of horse blood is quite innocent in itself, but it must be prevented from being repeated, for at the end of a hundred successive injections we should have a guinea pig whose blood would be identical with the blood of the horse.

Hence we see that *anaphylaxia is a method of defence for the species rather than for the individual.* It is immunization which forms the process of defence in the case of the individual, but it is anaphylaxia which comes into play to maintain the fixity of the species. But we are well aware that nature seems to care but little for individuals and that her great preoccupation is the keeping stable of the life of the species from generation to generation.

This concept of the rôle belonging to anaphylaxia is evidently pure theory—nevertheless it is perfectly admissible for we can scarcely permit ourselves to believe that there can be any general organic tendency which is quite useless to the species—and even less can we believe that there exists a tendency which is actually harmful either to the individual or to the species.

ANTI-ANAPHYLACTIC TREATMENT

Recent efforts of medical men have been directed toward combating the anaphylactic effects described. The theory first advanced by the well-known French scientist Portier and Ch. Richet was that the disturbance in question was due to the production of a poison to which the name of ato-toxin was given, and acting upon this theory an attempt was made to lessen the supposed toxicity of serums either by heat or by chemical means. The results thus obtained, however, were either uncertain or inadequate.

Besredka's Discovery.—In 1907 Besredka begun a series of experiments by means of which he discovered that an animal which has been *sensitized*, *i.e.*, one which has received a first injection of the anaphylactic substance, can be protected from the shock which commonly follows the second injection, if previous to the second injection a small quantity of the same substance, *i.e.*, of the *antigene* be injected. Since making this discovery Besredka has improved his process by making use of the method known as *subentrant* injection. This method consists in making three or four preventive injections instead of a single one at intervals of a few minutes, the quantity of serum employed being slightly increased at each injection. In this manner the patient is made to acquire an anti-*anaphylactic condition* which enables him to receive doses of the same serum without shock which might otherwise prove dangerous or even fatal.

Besredka offers an interesting hypothesis to explain this result. He believes that the successive injections of the antigene progressively neutralize the poison by producing a series of very small shocks or disturbances, each of which is so light as to be practically imperceptible, yet whose combined effect is sufficient to neutralize the antibody (*i.e.*, the poison producing substance), so that the patient is restored, so to say, to a "fresh" state.

This concept of the matter which, as we have said, was inspired by Richet's chemical theory and which assumes a narrowly specific character of both the antigene and the antibody, is contradicted by various facts according to Dr. J. Laumonier, who discusses the matter in *Larousse Mensuel* (Paris) for May, 1921. According to this authority both Roux and Besredka himself have found that certain narcotic substances, such as ether, alcohol, etc., prevent the production of the shock in sensitized animals, because, as they suppose, the state of narcosis makes it impossible for the nervous system to react and produce the characteristic phenomena of the anaphylactic shock. But this explanation, likewise, finds critics. Kopaczewski obtained the same preventive action with aqueous solutions of chloroform and of ether which were so weak as to be absolutely incapable of producing anesthesia. But even before this Friedberger had succeeded in preventing the shock by the simple injection of salt water; Billard and others had done the same thing by the injection of certain mineral waters employed in an emergency; Kopaczewski and Vahram by injections of oleate of soda; and Kopaczewski and Roffo by injections of bicarbonate of soda.

In 1919 Richet, Brodin and Saint Girons found that the second injection of serum became harmless if diluted with 9 times its weight of physiologic salt solution; in 1920 Lumière and Chevrotier, attributing anaphylactic disturbances to the formation of a precipitate in the bodily humors of the sensitized subject, discovered that the hyposulphite of soda prevents this precipitation and thus destroys the ill effects of the second injection.

From all these facts and others which might be cited it is clear that the anti-anaphylactic action does not depend upon a *chemical* combination, and is consequently not *specific* in character, since the most various substances are capable of producing it.

Hence we are impelled to seek a *physical* explanation, *i.e.*, one dependent not upon chemical affinity, but upon the physical properties of the humors of the body and of the substances introduced therein, and particularly those properties which are connected with the colloidal state, absorption and multiplication of the surface of contact, electric charge, superficial tension, viscosity, osmotic power, etc. From this point of view the concept of Danysz is more satisfactory, in spite of the fact that it is formulated in chemical language.

It is his belief that the anaphylactic poison is not formed until the antigene of the antibody is present in certain proportions; this is why a certain length of time is required for the introduction of the antigene (the first or preparatory injection) to produce a sufficient number of antibodies. If, when this amount is arrived at, a new dose of the antigene is injected in the quantity desired, there is a formation of poison, whose pressure is betrayed by the anaphylactic shock. But if, instead of the full amount of the desired dose one or more weaker doses are injected, there is no longer a balance between the antigene and the antibodies; the poison is not formed, and not only is there no shock, but the subject is desensitized once more. In other words, expressed in terms of physics, any substance (the antigene) capable of disturbing the equilibrium of the colloid of the serum or of the bodily humors of the subject, produces an immediate reaction (the hemoclasic crisis, or colloidoclasia of Widal) whenever there is a great difference of structure between the serum and the body injected, such as microbes, colloidal metals, sugar, alkaloids, arseno-benzols; and a very different reaction, on the other hand, if the difference is comparatively slight, as when therapeutic serums, extracts of organs, or foreign albumens are injected. In the latter case (anaphylaxia), and for the very reason of the structural resemblance of the bodies thus brought together, the modification of the humors is slow, so that the condition of unstable colloidal equilibrium is arrived at only little by little. If at this moment a sufficient dose of the antigene be injected, there is a definite rupture of equilibrium—in other words, a *shock*. But the characteristic features of a physical rupture of equilibrium in colloids, *i.e.*, of their destruction—consist in floculation, agglutination, and precipitation.

In order to avoid shock, therefore, in a sensitized subject (whose colloids are in a state of stable equilibrium) the physician should administer either very small doses of the "releasing" body (*i.e.*, the second injection of serum) thus accustoming the organism to rapidly digest and assimilate the precipitate formed, according to the Besredka process; or else he should inject substances capable of acting as stabilizers of colloids, such as alcohol, ether, sodium chloride, and the carbonate or the hydrosulfite of soda, which prevent the formation of the precipitate.

Evidently this *physical* explanation regards only the physical reactions of colloids: electric charge, surface, tension, viscosity, absorption, power of interference and of assimilation, etc., and does not concern itself with the chemical reactions

which doubtless also play a part, but one which is secondary or ulterior because of the small amount of the injected bodies.

But whatever the validity of the theories, which demand further study in practice, the anti-anaphylactic treatment as applied to man is definitely successful . . . since all of the various treatments described above protect the patient from the evil effects of anaphylactic shock.

THE CRADLE OF MANKIND

One of the much debated questions of anthropology, ethnology, and kindred sciences, is the location of the Garden of Eden, to speak symbolically. In other words, the situation of that part of the world where prehistoric man first began his long climb toward ascendancy over other animals. Modern theories offer various new suggestions which are briefly discussed in the monthly supplement of the *Chemiker-Zeitung* (Berlin) for August 1920. This writer remarks that it is only quite recently that some doubt has been felt with regard to the accuracy of the earlier theories. It is beginning to be a more and more widely accepted view that human beings originated, in all probability, in at least three different points on the globe, though probably during the same geological epoch, i. e., in the Tertiary Period. The very great differences in bodily structure exhibited by mankind have led to the belief expressed by Dr. Klassen in *Kosmos* (Berlin) for June 1920, that mankind is not to be considered as a uniform species, but that white men differ so much, from negroes on the one hand and the Australian races on the other, that they are to be regarded as forming three distinct families.

Robert Koch was led to this same conclusion through his studies of African diseases. Moreover, certain discoveries, especially those made by Horst, Arldt, and Melchers, also support this view of the manifold origin of the human race. These discoveries appear to indicate that there are three main roots each possessed of characteristic marks, such as are today to be observed in the three main divisions of the great Manlike Apes, namely, the Chimpanzees, the Gorillas, and the Orang-Outangs. These characteristics are designated as the Chimpanzoid, the Gorilloid, and the orangoid marks, and they are respectively to be found as regards their original home, in Western Europe, in Western Asia or Southern Asia, and in Eastern Asia.

These same divisions are quite manifest in the various races of human beings. Thus, there are three chief races among mankind, the white Europeans, the black woolly or crinkly haired Africans, and the yellow sleek-haired Asiatics. Of course, during the course of human history there has been every degree of intermixture among these three chief original races, so that today it is scarcely possible, indeed, to find absolutely pure descendants of any one of the original root races in any quarter of the earth. Even among the natives of America modern anthropologists are of the opinion that three root races can be proved to have existed. It is certainly an uncommonly instructive fact that among the American natives there are to be found not only the Ethiopic type and the Mongolian type, but the European type.

THE BODILY HEAT OF YOUNG ANIMALS

Some very interesting experiments have recently been carried out by a German scientist, Professor Leichtentritt, in the Physiological Institute of the University of Hamburg, with respect to the bodily heat of new-born animals and birds, such as dogs, cats, rats, guinea pigs, fowls, sparrows and thrushes. Tests were made by means of an oxygen respiration apparatus and a sensitive thermometer, and some interesting discoveries were made, especially in regard to the physiological processes in birds. In the case of kittens and guinea pigs the amount of heat appeared to depend upon the strength of the animal, which was conditioned by the number in the litter. Strong animals, weighing from 145 to 190 gr. are born, as a rule, with a fully developed system for heat regulation, and weaker ones weighing less than 100 gr. also show traces of such a system, since, when the temperature of the outer air falls they show an increasing use of oxygen, but one which is insufficient to maintain the heat of the body for a very long time. By the time they are 24 hours old, however, the young creatures were always found to have developed the power of producing heat in the blood to such an extent that in the same degree of temperature they used twice as much oxygen as at first, and when there was a very great fall in temperature the increase of oxygen used was fully 96 per cent more. In the case of small chicks the results were similar. Cockerels, weighing 68 gr. and having a body temperature of 35°C. maintained their temperature until the outer air had cooled down to 19°C., but by the time the thermometer had reached 14°C. the temperature of the blood had fallen to 20°C., without appearing, however, to cause the little creature any discomfort.

Different results were observed in the case of young birds. Young sparrows, whether still quite naked and blind, or whether two weeks old and almost full-fledged, exhibited only a very slight and insignificant increase in the consumption of oxygen upon a fall of temperature from 31°C. to 18°C.—an increase so small that it was not sufficient to maintain the temperature of the blood. Obviously, therefore, the system of heat regulation is much poorer in nestling birds than in mammals and young chickens. When the outer temperature fell to a temperature of from 18°C. to 10°C., i. e., to a temperature which often occurs during the first breeding period, the consumption of oxygen and the temperature of the blood showed a marked decrease; but whereas young kittens and chicks were frozen in the cold until they looked to be dead and it was difficult to restore them by artificial heat, the young sparrows and thrushes bore the same degree of cold with ease.

Hitherto naturalists have been inclined to regard this imperfect heat equilibrium in young birds as a sign, together with the helplessness of the blind and naked little creatures, of a certain degree of imperfection on the part of nature; but now the opposite opinion must be held. Even on fine, warm days it is not an easy matter for the parent birds to get enough food for their brood, while on the cold and rainy days which are so frequent in the spring of the year, the difficulty is, naturally, greatly increased, since on such days insects creep into hiding places and vegetable food is also scarcer and harder to get; on such days, too, the adult birds themselves need more food than usual on account of the cold; but because of the longer absence of the parents from the nest and the consequent cooling off of the young birds, the consumption of oxygen decreases and on this account the young birds' need of food is correspondingly diminished.

But aside from the question of food the apparent imperfection of nature in the helplessness exhibited by young birds works for good, since it notably strengthens the affection between the parents and the offspring and tends to increase their devotion to their home. Professor Leichtentritt has given convincing proofs that all of the motions made by the young sightless birds in taking food, such as the stretching of the neck, the raising of the head, the opening of the beak and the peeping noise they make are reflex imitations, so to say, of the motions made by their elders: the first being occasioned by a comparatively violent shaking of the nest, the second, by the call of the parent, and the third, by the cutting off of the light through the shadow thrown by the parent's body. The proof of this is found in the fact that these three kinds of reflex action can be incited by artificial means, *i.e.*, by shaking the nest, by making a sound similar to that made by the parent bird and by using the hand to throw a shadow—this latter experiment is sometimes performed by extinguishing one of two lighted electric globes. The fact that the young bird gives a feeble or a strong response to the reflex in question may depend upon the comparative fullness or emptiness of its stomach, or upon the warmth or chilliness of the air. In all cases the elder bird is conscious from the behavior of its young ones how greatly dependent they are upon its faithful care, and this strengthens its own fidelity to the nest.

The Marquis of Worcester and the Steam Engine

An Interesting Figure of the Seventeeth Century and the Claims Advanced on His Behalf

By Herbert T. Wade

IN the entire history of invention it is difficult to find a more interesting and picturesque figure than the Marquis of Worcester, for whom with considerable plausibility claims have been and are advanced for the honor of being the inventor of the steam engine. He has left us an interesting volume of description of a number of his inventions, while history and contemporary records tell much of his political activity; yet in the special field where his work was of extraordinary importance there is a surprising lack of detailed and exact information sufficient to enable the technological historian to announce unreservedly whether this English nobleman-inventor was the first to make in practical form a useful application of steam. Nevertheless there are many arguments to be advanced in support of the claim that he was the inventor of the steam engine in the first of its stages, namely, that of fire engines, and the facts on which such a claim is based, in connection with the personality of the inventor as shown in his writings and otherwise, make a record of rather more than mere antiquarian interest.

The Marquis of Worcester, or Edward Somerset to give his family name, was born the first son of the fifth Earl of Worcester in 1601. This was a year before James I. was proclaimed king of England, and taking an intellectual inventory of the period there would be revealed such facts as the birth of Milton in December, 1608, and the death of Shakespeare in 1616. In 1611 the King James version of the Bible was published, while about this time (1618) the system of logarithms known from its inventor, Lord Napier of Scotland, was being introduced. William Harvey was announcing (1616) the circulation of the blood and Sir Hugh Myddleton was developing (1609-1613) the New River to supply London with water from springs in Hertfordshire. Another landmark was the death in 1626 of Lord Bacon.

Known at first as Lord Herbert, Edward Somerset was educated privately at his father's seat, the Castle of Raglan in Monmouthshire, and later traveled extensively in Europe. In the course of his education his attention and tastes turned to geometry and mechanics. It must be recalled that at this time chemistry had not been released from the mystical shackles of the earlier alchemy and that England was sadly deficient in men of engineering and mechanical skill. To secure those competent to handle the various public works and other engineering projects which the development of British civilization and industry demanded to an ever increasing degree, recourse was had to the continent of Europe for qualified workers. Lord Herbert, however, was interested in mathematical studies, not only on the intellectual side, but his mind was inclined to the practical and he early engaged in reducing to practice his many ideas. In 1628 he was fortunate to obtain for the mechanical development of his various experiments and inventions one Caspar Kaltoff, a German mechanician whom he described as an "unparalleled workman both for trust and skill." Without doubt this worker was established in what was for that time a well-equipped laboratory or workshop and contributed to his master's success. At Raglan Castle it was possible to develop a succession of inventions of consequence and otherwise, ranging from merely amusing toys and automata, devices for making correspondence secret, etc., to ordnance and mechanical apparatus of possible importance and value. These inventions of course included at least one machine for perpetual motion, constructed some time between 1638 and 1641 and exhibited before Charles I. and other notables at the Tower. This machine was of the familiar type having balls attached to the periphery of a rotating wheel.

On account of his friendship for the King and service with the Royalist forces, the inventor suffered serious reverses and was forced to go to France as a voluntary exile, returning to England in 1651 only to be apprehended and confined in the Tower of London, where until 1654 or 1655 he was in more or less close custody. During this interval his mind was active; in fact, as in the case of other reputed inventors of the steam engine, tradition, without the slightest foundation, ascribes to him the familiar experience of watching the vibrating lid of a boiling pot and thereby receiving his realization of the force of steam. This phenomenon Lord Bacon refers to in his essay on the Origin of Invention. In 1655 the Marquis, (his title of Earl of Glamorgan from Charles I. was now repudiated) prepared in manuscript form that interesting record and description of his inventions under title of the "Century of Inventions." On his release from confinement in the same year he began an active campaign to develop and introduce his water-commanding engine, in which he had unbounded hopes. He sought to purchase land and buildings at Vauxhall for further development of this machine or apparatus, it being very likely that this site previously had been the scene of various engineering and ordnance undertakings in which the Marquis may have had a part. His projects and schemes for the water-commanding engine figure, though without satisfactory mechanical details, in many documents of the period, the most notable one dating to 1663, when Parliament passed an act giving to the Marquis and his heirs for 99 years a patent for his water-commanding engine. With such frequent reference to this invention it is natural for the reader to expect some full description of it, even from the slight details available and the fragments which antiquarians have pieced together almost in the way of circumstantial evidence. Thus in 1664 M. Sorbiere, historian to the King of France, in a small work published in Paris entitled "Relation d'un Voyage en Angleterre," etc., says:

"One of the most curious things I wished to see was a Hydraulic Machine, which the Marquis of Worcester has invented, and of which he has made experiment. I went expressly to Vauxhall, the other side of the Thames, a little below Lambeth, which is the Palace of the Archbishop of Canterbury, in sight of London. The machine will raise to the height of 40 feet by the strength of one man, and in the space of one minute of time, four large buckets of water, and that by a pipe or tube of 8 inches." Another reference, but rather contemptuous in nature, is that in which Dr. Robert Hooks, in a letter of 1667 to Robert Boyle, refers to the Marquis of Worcester's water-commanding engine, styling it after an examination as "one of the perpetual motion fallacies."

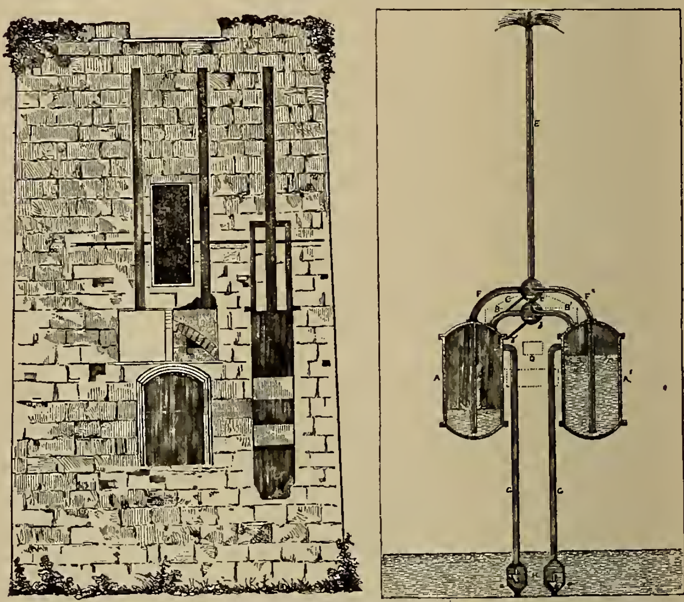
Further evidence of an eye witness is to be found in the Travels of Cosmo de Medici the Third, Grand Duke of Tuscany, who visited England and on May 25, 1669, "went to see an hydraulic machine upon a wooden tower in the neighborhood of Somerset House which is used for conveying water of the river to the greater part of the city." And on the 29th of the same month it was also recorded that "His Highness, that he might not lose the day uselessly, went again after dinner to the other side of the city, extending his excursion as far as Vauxhall, beyond the palace of the Archbishop of Canterbury, to see an hydraulic machine, invented by my Lord Somerset, Marquis of Worcester. It raises water more than forty geometrical feet by the power of one man only; and in a very short space of time will draw up four vessels of water through a tube or channel not more than a span in width; on which account it is considered to be of greater service to the public than the other machine near Somerset

House." This all is interesting in that the Marquis of Worcester had died on April 3, 1667, and his water-commanding engine doubtless was in operation from 1663 to 1670. But still the reader has not been informed as to its nature. The Marquis in his "Century of Inventions," Article 68, informs us of "An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upward." He states further: "I have seen the water run like a constant Fountaine-streame forty foot high; one Vessel of water rarefied by fire driveth up forty of cold water. And a man that tends the work is but to turn two Cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise abundantly perform in the interim between the necessity of turning the said Cocks." Then again in Article 98 the Marquis refers to "An Engine so contrived, that working the Primum Mobile forward or backward, upward or downward, circularly or cornerwise, to and fro, streight, upright or downright, yet the pretended Operation continueth and advanceth none of the motions abovementioned, hindering, much less stopping the other; unanimously, and with harmony agreeing they all augment and contribute strength unto the intended work and operation: And therefore I call this a *Semi-omnipotent Engine*, and do intend that a Model thereof be buried with me." But no such model ever was found when the tomb years after was opened with this object, and the description which certain enthusiasts interpret as meaning a piston engine finds no support either in contemporary record or history. Finally in Articles 99 and 100 the Marquis refers with enthusiasm to a device to raise weights based on the principle of the condensation of steam and a water work or pump, where "A child's force bringeth up an hundred foot high an incredible quantity of water, even two foot Diameter, so naturally, that the work will not be heard even into the next room; and with so great ease and geometrical Symmetry, that though it work day and night from one end of the year to the other, it will not require forty shillings reparation to the whole engine, nor hinder one's day-work." And then with the modesty, "I may boldly call it '*The most stupendous work in the whole world*'; not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as to keep them sweet, running through several streets, and so performing the work of Scavengers as well as furnishing the Inhabitants with sufficient water for their private occasions; but likewise supplying Rivers with sufficient to maintaine and make them portable from Towne to Towne, and for the bettering of Lands all the way it runs; with many more advantageous, and yet greater effects of Profit, Admiration, and Consequence."

Now while the descriptions, of which the foregoing are extracts, hardly warrant the promise of the author of the "Century" that the volume contains only those inventions he can call to mind to have "tried and perfected," yet taken with other data they enable the enthusiastic though partisan biographer of the Marquis of Worcester, Henry Dircks, to reconstruct the original water-commanding engine, at least to his own satisfaction, and to base thereon a claim for the invention of the steam engine. His sectional drawings, he asserts, meet the conditions of the description, and with such apparatus water could be raised to a vessel or reservoir through condensation, and then forced to a further distance above simply by turning the valves by hand and keeping the furnace fire burning. The method will appear from Dirck's description of his diagram.

With this reconstruction, which embodies all the various elements and descriptions, we can go back to the days at Ragland Castle before the "Century" was published, and after a consideration of the ruins presume that such a water-commanding engine was here installed. Evidence in support of this theory was sought in the remains of the castle citadel or keep where certain mysterious grooves were found and assumed to house the pipes and reservoirs of such an engine, where the heat from burning fuel produced steam in a vessel or boiler containing water, which in turn acted to drive water through vertical pipes to a considerable elevation, presumably a large cistern on the summit of the citadel. The accompanying illustration shows the walls of the citadel with the grooves and cells in which such an assembly of boilers, pipes and reservoirs might have been installed. To Dircks the evidence of the ruins and the records and fragments seem clearly to demonstrate the first practical application in a primitive form of a means of employing steam as a useful mechanical agent and thus placing the Marquis of Worcester in the position of being the inventor of the steam engine. But in the same way we might go back to before the Christian era and consider the Aeolipile as the first useful application, or such predecessors of James Watt as De Caus (1615) with his hot water fountain, Branca (1629) with his steam jet driving a small mill, Savery (1700) with his engine to raise water, etc.

It is of passing interest to refer briefly to some of the



THE "WATER-COMMANDING ENGINE" AS RECONSTRUCTED BY DIRCKS, AND THE FACE OF RAGLAN CASTLE, SHOWING THE MARKS THAT ARE CLAIMED TO INDICATE ITS INSTALLATION THERE

DIRCKS EXPLAINS HIS DRAWING AS FOLLOWS:

A,A′ are two cold-water vessels connected by B,B′, the steam pipe, with C, the boiler, set in D, the furnace. The cold-water vessels A,A′ also are connected with E, the vertical water pipe, by means of F,F′, continuations of the same pipe conducted into and nearly touching the bottom of each vessel A,A′. G,G′ are two water supply pipes, with valves a, a′ dipping into H, the well. It is obvious by uniting these pipes, and placing the valves in the upper bend of each, it would be sufficient for a single pipe to dip into the water to be raised. On the steam pipe BB′ is *b*, a four-way steam cock operated by *b′*, its lever handle; and on the horizontal portion of the water pipe FF′, is *c*, a four-way water cock, operated by *c′*, its lever handle.

other inventions made by the Marquis and duly described in his "Century of Inventions," which is a remarkable commentary not only on his personal characteristics and tastes but on the times in which he lived. Here was a period when mechanical curiosities were considered a favorite pastime of the intellectuals. The Marquis used the term inventions rather loosely, as many of the devices or methods he set down as original he had seen in the course of his travels or perhaps were common practice of the time, as, for example, a system of shorthand, of which he wrote several kinds as well as different forms of ciphers. But the Marquis was broad in his tastes, even if many of his descriptions deal merely with mechanical toys without practical application, and it is interesting to examine even the classification of this extraordinary collection. Of the various inventions 3 refer to seals and watches, 2 to games, 2 to arithmetic and perspective, 6 to automata, 23

to correspondence, ciphers, and signals, 10 to domestic affairs, 9 to mechanical appliances, 32 to naval and military affairs, and 13 to hydraulics and the water-commanding engine. Some of the devices described rather test one's credulity, as in No. 77 he tells "How to make a man fly; which I have tried with a little Boy of ten years old in a Barn, from one end to the other on a Hay-mow." Several of these inventions were demonstrated before the king.

It must be realized in this as in other connections, that the times of the Civil War and Restoration were not favorable to the keeping of orderly records. But there is little evidence to indicate that the Marquis of Worcester had, as he said in his preface, "tried and perfected" as many of the inventions as he claimed. To him, however, invention was indeed a pleasure and a passion, for as he wrote in the "Century" Dedication, "The more that you shall be pleased to make use of my inventions, the more inventive shall you ever find me, one invention begetting still another." Such was the picturesque character for whom the invention of the steam engine is claimed. It is doubtful if further antiquarian research can do more to substantiate his title, and while one cannot avoid a certain skepticism, yet there is undeniably a fascination and sympathy with the work of this scientific nobleman, who with better fortunes would unquestionably have made good some of his hopes and aspirations to replace human or animal power with the giant force of steam.

THE OPPAU PLANT

The quest for new sources of nitrogen, one of the most important, world-wide technical problems of the day, has led to the development of a very remarkable plant in the little village of Oppau on the Rhine in Germany. It was this plant that furnished Germany the nitrogen required for fertilizing the land and manufacturing explosives during the war. It was practically the *sine qua non* of Germany's existence as a belligerent, and now it has made Germany practically independent of Chilean nitrate as far as the requirements of her peaceful industries and enterprises are concerned.

Chile, as is well known, is the only commercial source of nitrate, and while her deposits of this all-important chemical are not nearly exhausted, nevertheless, the world has chafed against her peculiar monopoly and technologists long ago sought to find other sources of this commodity. The manufacture of nitrogen from the air has been carried on on an industrial scale successfully in this plant in the little village of Oppau.

There, the process, known as the Haber process, is being exploited. This process relates to the making of ammonia from the nitrogen in the air, and the subsequent oxidation of it to nitric acid. The plant is owned by the well-known dyestuffs concern, The Badische Aniline und Soda Fabrik. The plant can make 300 tons of ammonia a day, which is equivalent to 1,100 tons of ammonia sulphate.

The nitrogen that is required in the manufacture comes from the air, and the hydrogen, the other constituent of ammonia, whose manufacture has always been a very difficult problem to solve technically, has been produced successfully from a mixture of water gas and producer gas by a catalytic process. The gases were made not from coal but lignite. In the course of this manufacture a tar was recovered which was worked up afterward into a lubricating oil. This oil was used throughout the entire plant and gave very satisfactory results.

The various processes used in the plant are very intricate and require supervision by technically-trained men. After the nitrogen and the hydrogen are obtained in a very pure state, then they are catalyzed into ammonia at a high temperature and low pressure. The French chemist, Claude, has developed a process where pressures of many atmospheres are used. The ammonia is then oxidized to nitric acid with an efficiency of 80 per cent. The plant can oxidize 180 to 200 tons of ammonia a day. The nitric acid is concentrated by mixing it with sulphuric acid and denitrating the mixture in a tower. Ammonia sulphate, for fertilizer purposes, is made from gypsum and ammonia liquor. The capacity of this plant is 1,600 tons of gypsum a day. In addition, ammonium chloride and Solvay soda are also produced. The ammonia and the weak nitric acid are made into ammonium nitrate for use in explosives.

The plant construction was commenced in 1912. It covers 2,000 acres and cost about 18 million dollars on the pre-war rates of exchange. It employs 5,000 men of which 2,000 are in the shops. There are 60 engineers and 500 technical superintendents and foremen.

MOLECULAR STRUCTURE IN FIBROUS MATERIALS

Dr. R. O. Herzog and Willi Jancke.

M. v. Laue, Friedrich and Knipping demonstrated the fact in 1912 that a bundle of X rays allowed to pass through a crystal and fall upon a photographic plate placed behind the latter, formed points upon the sensitive plate giving indications of the position of the atoms in the crystal, arranged in the form of a space lattice. This discovery was of the most basic importance with regard to our knowledge of solid bodies. Somewhat later the two Braggs, father and son, suggested another method, while the third was proposed by Debye and Scherrer (see *Umschau*, 1920, Bo. 34). These methods made it possible to examine a very finely pulverized substance in order to determine whether the powder had been made from a crystal or from an amorphous body.

More recently we have applied these methods to the examination of fibrous materials (see *Berichien d. deutsch. Chem. Gesell.*) (Reports of the German Chemical Society, page 2162, 1920.) With this purpose, cotton, for example, was torn apart, compressed into a small rod and an X ray was passed through it. If the reflected radiation be received upon a film bent into the form of a circle, there will be obtained, just as in the case of a powdered crystal, blackened lines, sections of the film with circular spherical balls which, starting from the *fibers, surround the X ray. If, on the other hand, the fibers* be laid parallel and the X ray directed upon them vertically, there will be symmetrically arranged points produced upon the photographic plate behind them. From X ray photographs obtained in this manner from cotton, ramie, flax, wood, cellulose, jute and sawdust, it was learned that the cellulose is present in plants in a crystalline condition, and is, likewise, symmetrically arranged along the main axis of the fiber.

An examination of artificial silk shows that this material consists of splinters of crystals, of chemically altered cellulose, connected in irregular chains. Artificial silk made from acetyl cellulose, is amorphous and consists of a mixture in which the acetyl cellulose has undergone extensive decomposition.

Natural silk, on the other hand, exhibits a crystalline character, and possesses a symmetrical structure similar to that of cellulose.

The hair of animals, on the contrary, is amorphous, being apparently built up of two or more different substances.

Starch proved to be crystalline, as was suspected by Naegeli, while glocogen, *i.e.*, starch obtained from the liver of animals, is amorphous. Pure fats are crystalline.

It is of interest to learn from these experiments that the different kinds of cellulose, the different kinds of starches, and the various forms of silk exhibit no difference in the above respect in spite of the most various origin.

This sort of experimental study is merely beginning, but it may be looked forward to to enable us to comprehend the physical properties of various fibers. In this manner such properties as tenacity, behavior with respect to dyes, swelling, shrinking, etc., may probably be explained scientifically through the information obtained as to the physical structure of the fibers, so that eventually they may be controlled by the technological expert.—From *Die Umschau* (Frankfurt a. m.), Jan. 29, 1921.

THE STANDARD DECORATIONS OF THE UNITED STATES ARMY AND NAVY

Left: In order, the Army Medal of Honor, Distinguished Service Medal, and Distinguished Service Cross. *Right*: Corresponding Medals of the Navy, in the same order

"Pomp and Circumstance"

Military and Naval Decorations, Uniforms and Insignia After the War

By Albert A. Hopkins

Author of Our Army and How to Know It—Our Navy and How to Know It, etc.

THE grim memories of the late war are still with us and for generations we shall feel the aftermath of the gigantic struggle. The useful by-product of the war has been small, with the exception of chemical industry, which has come into its own. Of course, the art of war has "improved" if we can call more successful methods of man-killing and man-maiming and ship-sinking an improvement, and all the blood spilled and treasure wasted ought to have brought out many things for the "Art of War." In one small particular the war has made large changes: this is in relation to uniforms, orders, decorations and insignia.

Before the war the uniforms of nearly all nations were gaudy in the extreme imperiling the safety of men in the field, and our own country was quite a sinner in this respect as our pictures of the former army and marine uniforms show. Now all this is changed and the sober olive drab and khaki and forest-green will probably always be in use for everything germane to the practice of the profession of arms.

Insignia suffered enormous changes in the war and we shall duly chronicle some of them which are of far-reaching importance; decorations have also come into their own. Orders have received new significance and under new policies can now be worn by those who have deserved them. This article was prompted by the appearance of a new book on the subject which makes a fitting capstone to the not-too-large-pile of works on the subject. We are referring to a beautiful book just issued by the Putnam's entitled "Orders, Decorations and Insignia, Military and Civil," with a history and romance of their origin by Colonel Robert E. Wyllie of the General Staff of the U. S. A. It is very appropriate that a work of this kind should be written by an army officer who is thoroughly in touch with all phases of the intricate questions involved. This article may be regarded as very largely an illustrated review of this book, although the illustrative material is derived elsewhere, one reason being that many of the illustrations in Colonel Wyllie's book are beautifully executed in full color which would pale to insignificance if reproduced in monochrome. There are twelve color plates in all and their excellence fully warrants the publishers in putting out a book at a relatively high price—a work which contrasts in an amusing manner with the present writer's modest attempt at insignia elucidation, published during the war at a quarter and sold to the number of nearly 200,000.

UNITED STATES VICTORY MEDAL, WITH ARMY AND NAVY CLASPS, AND A COMPLETE SET OF BARS, OF WHICH NATURALLY FEW MEN HAVE MORE THAN TWO OR THREE

HISTORY OF MILITARY AND NAVAL AWARDS

The author begins at the earliest historical record we possess of medals, which was an award made by an Emperor of China in the first century of the Christian era to his military commanders. There is brief mention of rewards and decorations down the ages, but we do not come to anything very substantial until Tudor times. The modern system seems to have been inaugurated during the reign of Queen Elizabeth, for in 1588 the famous "Ark in Flood" medal was awarded, presumably to commemorate the collapse of the expedition known as the "Spanish Armada." It derives its somewhat curious name from the bay tree in the middle of an inhabited island surrounded by an ocean. The whole is an eloquent exposition of Great Britain's insular position. This was only a naval medal and the army was not considered. Other medals were issued from time to time until 1650, when we find the first medal given to

officers and men indiscriminately. This was voted by Parliament in the time of Cromwell. A distinction was made, however, the officers received gold medals and the men larger medals in silver. These medals sometimes crop up in auctions and sell for about $100. The naval victories over the Dutch in 1653 resulted in several medals, but it was not until 1692 that medals for the rank and file came into being and it was not until 1773 that a general distribution of medals seems to have taken place in isolated instances, with special medals for individual persons, generally the commanding officer. It was the battle of Waterloo that finally broke down the barrier against military caste in the award of medals.

The history of decorations in our own country follows very closely British models, originally only the commanders being honored. The first medal bestowed by our Government was awarded to General George Washington to commemorate the evacuation of Boston by the British in 1776. Captain Paul Jones was similarly rewarded as were the captors of Major Andre. An order was issued from his headquarters at Newburgh on August 7, 1782, by Washington, which calls for a figure in the form of a heart in purple cloth or silk to be worn on the left breast. Colonel Wyllie states that this was our first decoration and the first in history which had a general application to enlisted men. Medals had indeed been given but no decoration for special merit. Although we have lagged behind nations in the matter of decorations we can at least be proud of the fact that our first decoration was a long way in advance of anything then in existence in any country. The War of 1812, the Mexican War and the Civil War all produced medals, although Colonel Wyllie says that at first there seemed a deep seated prejudice in this country against medals and decorations. In 1861 this settled policy was overthrown by the establishment of the Medal of Honor which remained our sole military decoration for nearly forty years. We entered the Spanish War in 1898 without medals and those that had received the Medal of Honor wore them only with full-dress uniforms. The system of wearing ribbons had not then come into vogue. All is now changed and we find uniforms with ribbons of all wars, besides medals and decorations. A false idea of democracy militated against the perfectly legitimate use of such devices, although the free use of decorations by our French sister republic would seem to show that such things were not opposed to democratic and republican institutions. The effect on the morale of troops is enormous and such medals and decorations hurt nobody. The Spanish War broke our spell, as it were, and a few months after the battle of Manila Bay all officers and men who participated in that action received medals. This was followed by other medals; the bars were down and campaign badges and ribbons came into common use.

Wide World Photo

BLANKET MADE BY A FRENCH WOMAN, INTO WHICH ARE WORKED THE SHOULDER MARKS OF MOST OF THE AMERICAN DIVISIONS

WORLD WAR HONORS

Then came the great World War with the heroes of our Allies gaining daily honors. We had nothing which filled the bill; we were hopelessly outclassed at every point by the superior arrangements of other powers. We were hampered with obsolete regulations, such as one which did not allow our officials to receive any rewards or decorations from foreign countries without the permission of Congress. Some of our Allies hinted, gently perhaps, but hinted all the same, that a recession from this position would be a real help to the cause, as it was. An agitation was started and finally, by executive order, the "Distinguished Service Cross" for extraordinary heroism, not calling for the Medal of Honor, and the "Distinguished Service Medal" for specially meritorious service in duties of great responsibility were established. Congress confirmed this action and allowed persons in the Government service to receive decorations and honors from governments with whom we were associated, such permission to expire one year after the close of the war; and the President was authorized to bestow American decorations on members of the military and naval forces of our Allies.

In February, 1919, Congress established two decorations for the Navy: the Distinguished Service Medal, corresponding exactly to that instituted for the Army, as described above, and the Navy Cross, to be awarded for heroism not justifying the award of a Medal of Honor, or for other meritorious service not warranting a Distinguished Service Medal.

The last act in this evolution occurred on the question of the Victory Medal, which is given to commemorate the World War. Heretofore it was our custom to bestow war medals only on those who participated in the campaigns. Those who had the misfortune to remain in the United States received no recognition, even though engaged on work vital to the success of the overseas forces. Soon after the armistice, it became evident that the sentiment of the country was against such a discrimination, and a bill was introduced into Congress to award a medal to all who served in the Army and Navy, regardless of whether or not they had overseas' service. This bill, due to the press of business in the last session of that Congress, never emerged

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THE FOURRAGERE OF THE FRENCH ARMY AND THE AIGUILLETTE OF THE NAVY, AND THE MANNER IN WHICH THEY ARE WORN

FANION OF THE AMERICAN AMBULANCE NO. 5—646 S. S. U. S., SHOWING CROIX DU GUERRE, OTHER MEDALS, AND FOURRAGERES

from the committee, but the principle was accepted by the War Department, and the order establishing the Victory Medal gave it to all who served on active duty during the war, and a system of clasps was adopted to denote participation in battle operations. This custom has been in force in Great Britain since 1813. Under it a much more complete recognition is given for services performed in wars than is possible by a medal alone. The medal itself is given to all who in any way contributed to the military operations, and in addition, clasps are awarded, to be worn on the ribbon above the medal, to show in which battles or campaigns of the war the wearer participated. The medal with its clasps gives a fairly complete record of the service rendered.

MEDALS AND DECORATIONS

"In its broad conception," says Colonel Wyllie, "a medal is a metallic ornament used for commemorative and decorative purposes, usually given as a reward or token. Originally medals were purely commemorative.... but it must not be forgotten that the majority are still struck primarily to commemorate events, therefore the design should be symbolical and artistic. A medalist in addition to being an artist must have imagination, a knowledge of heraldry and both ancient and modern symbolism, in order to produce a design which will be artistic, and at the same time will successfully portray the event in a simple manner. Our War Department is in close touch with the United States Commission of Fine Arts, and for some time that body has assisted in the design of medals and insignia, which insures artistic merit otherwise unobtainable.

"The word decoration is somewhat broader in its meaning than medal as it is not confined to metallic substances, however it has been found necessary to restrict the technical meaning of both these words, and a decoration can be defined as an insignia of honor bestowed for some individual act or service, in contradistinction to a service medal which is for general distribution, commemorative of some war, campaign, or other historical event, to all who honorably participated therein, irrespective of the value of their individual services. For example, a Medal of Honor is a decoration as it is bestowed for some signal act of heroism, but the Victory medal is not, as it is for general distribution to all who served honorably in the World War, it is therefore classed as a service medal. From this it can be seen that a decoration is a higher distinction than a service medal, and takes precedence thereof.

"An 'order' is virtually a society, and the honor conferred on the individual is being made a member of the order or society, so the insignia which is worn is the evidence of such membership; while in the case of a decoration proper it is the insignia itself which is the distinction awarded, there is no official society of the holders of decorations. The countries which have orders place them above decorations in precedence. The principal insignia of an order is called a badge. In addition, that word is applied in the United States to the insignia which are given to show qualifications in marksmanship, aviation, swordsmanship, etc., and also to the insignia of military and other societies. In general therefore the order of precedence places orders first, then decorations, then service medals and lastly the badges which show qualifications and membership in societies.

"The badges and some medals and decoration are made in the form of a cross or star, but the vast majority are circular-shaped like coins, so that a fairly close inspection is required to recognize the distinctions between them. To provide a ready means of identification each has a distinctive ribbon, so that by using different combinations of colors,

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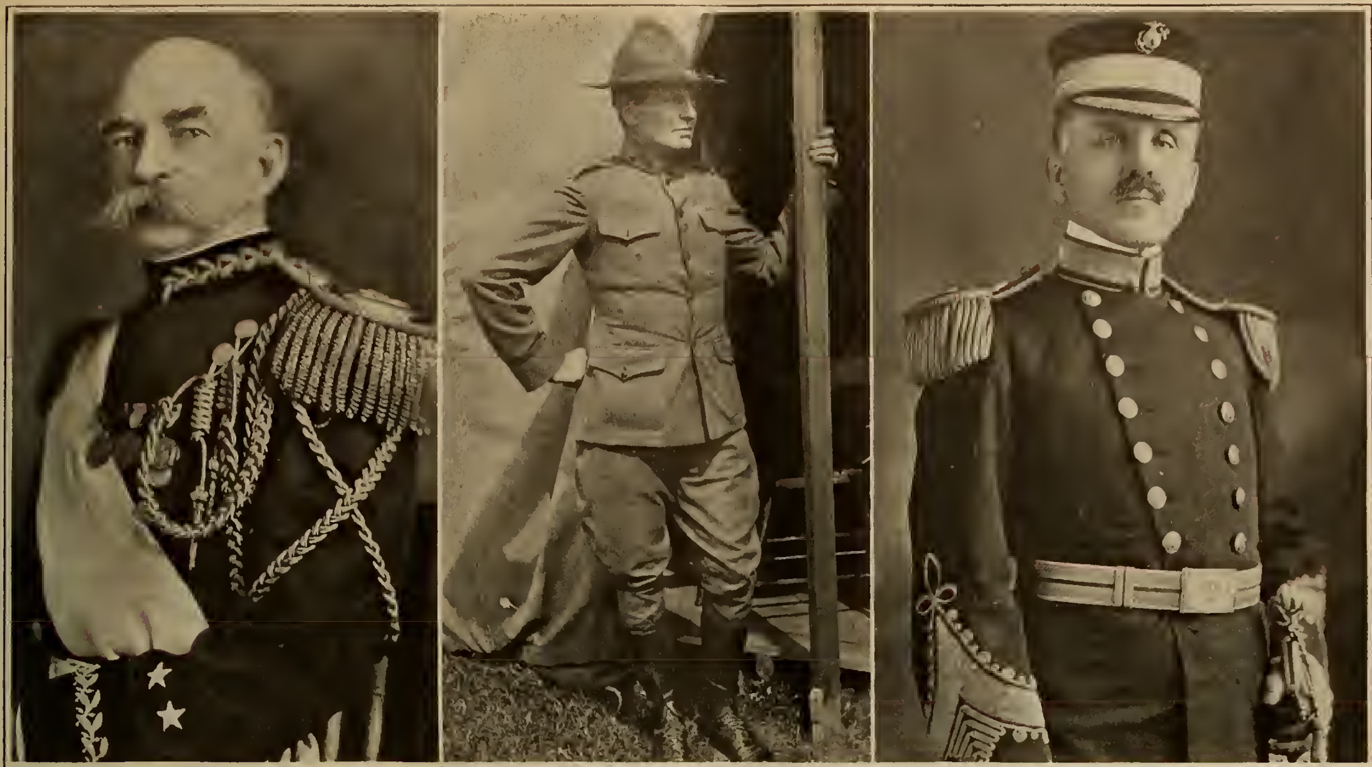
CORRECT WEARING OF DECORATIONS BY CIVILIANS



GOLD LACE AND EPAULETTES WENT INTO THE DISCARD WITH THE COMING OF WAR

Left: The old full-dress Army uniform. *Center*: The severely practical service uniform worn throughout the war. *Right*: The Marine Corps dress uniform

the particular decoration or medal can easily be identified. This ribbon also serves the purpose of providing a means of suspension for the medal itself, so it is an integral part of the insignia, the medal not being complete without its own distinctive ribbon. Ribbons are not used with the badges which show qualifications in small arms, etc., as those badges are either made in such a shape as to be easily recognized, or they have plain and legible inscriptions indicating exactly the purpose of the badge.

HOW MEDALS AND DECORATIONS ARE WORN

"In uniform it is customary for military men to wear decorations and medals only in full dress; this uniform has recently been abolished for our Army, but the principles still govern, as decorations and medals are now worn only on stated ceremonial occasions, when full dress would have been employed in former days. Even on these occasions the military man is limited to those awarded him by his own, an equal or a superior government; medals of inferior origin are not worn. To illustrate, a soldier of the United States Army, in uniform, should never wear a medal presented to him by a State, municipality, or society, but only those of the Federal Government or a coordinate foreign government. A State officer, on the other hand, can wear a medal presented to him by his own or any other State in addition to those awarded by the United States or a foreign government. but he should not wear a municipal decoration or society badge. This is on the principle that it is derogatory to the dignity of the government whose uniform is worn to ornament it with a decoration emanating from an inferior authority."

Colonel Wyllie then describes service ribbons and lapel buttons:

"Lapel buttons are used with civilian clothes for the same purpose. They are made in a variety of forms, rosettes, bowknots of ribbon, small pieces of ribbon, metallic buttons, buttons in enameled colors, etc., each decoration having its own particular design. Formerly rosettes made of silk ribbon of the same colors as the ribbon of the medal were used by the United States for lapel buttons, but they were not sufficiently distinctive, for example, the army has four medals with red, white and blue ribbons, the navy has the same number in red and blue, and it is impossible to make rosettes in those colors so that the differences can be easily remembered and applied. As a result in 1919 we adopted as a lapel button, a miniature of the service ribbon made in colored enamel. This is now used for all our decorations and medals except the Medal of Honor and the Victory Medal, the former retains its old rosette which is hexagonal and of light blue with thirteen white stars, consequently very distinctive. A colored enamel representation of the rainbow of the Victory ribbon would be difficult if not impossible to make, and the lapel button for that medal is a star on a wreath with 'U. S.' in the center, and is usually called the 'Victory button.'"

Colonel Wyllie makes some excellent remarks about wearing medals on evening clothes, the open front and the lightness of the material militating against the wearing of medals, and miniature reproductions are usually substituted, the scale being one-third to one-half. Of course, the full-sized article and the miniature replica should not be worn simultaneously. On the death of the rightful possessor of a medal or decoration, it should be presented as an heirloom but never worn by any one. Where posthumous honors are given to the next of kin the person holding the same has no right to wear the article.

A "Citation" is an official announcement of appreciation for services performed. It is bestowed in various ways and does not necessarily carry any other reward. Membership in an order is usually conferred in a document called a brevet, which is given to the new member and is the official evidence of his membership. The distinction between award and presentation should be clearly established. A citation which specifically bestows a personal decoration is the award; presentation is when the decoration is actually received. The award is always to the individual who earned the decoration, even though he may have died in the meantime. Whenever possible it is also presented to him and with considerable formality and ceremony, but this is not essential, presentation can occur to any one deputed to receive it. In the case of a Service

Medal the order announcing the qualifications for any particular medal is the award to all who are covered by the order. These medals are rarely presented with formality but are issued to those entitled to them in the most convenient manner.

Medals and decorations, with but few exceptions, are worn on the left breast and in a carefully arranged order of precedence. The place of honor is to the right of the wearer, nearest the center line of the breast, and the highest decoration possessed is worn in that position. Others follow in the correct order of precedence, and then service medals according to the dates of the services rendered. Foreign decorations are worn after all the decorations and medals bestowed by the wearer's government and in the order of the date of receipt. Our Medal of Honor is worn at the neck and it is considered a higher position than on the breast. The service ribbon however is worn on the breast with the others but to the right of them all. When any decoration is worn at the neck the ribbon from which it is suspended is placed around the neck inside the collar so it does not show. With a uniform buttoning up to the neck, the ribbon comes out between the top hooks or buttons, the medal hanging about one inch lower. In evening clothes the medal hangs just below the tie.

OUR DECORATIONS

Colonel Wyllie then describes in great detail the history of American decorations including the Medals of Honor, the Distinguished Service Medals, the Distinguished Service Cross. There are two Medals of Honor, one for the army and one for the navy; these are different decorations each governed by different acts of Congress under the same conditions of award, so it is possible for a person of almost medieval bravery to obtain one of each but this situation has never occurred. For a second act warranting a rebestowal of the Medal of Honor *in the same service* a bronze oakleaf cluster is awarded. This is worn on the ribbon of the medal and a miniature thereof on a service ribbon. No case of this kind has occurred and the navy has no device in lieu of a second award. Colonel Wyllie states that there are 1795 on the Medal of Honor roll of the army and of this number 78 were awarded for heroism during the World War—19 were posthumous awards, 58 went to enlisted men, 16 to junior officers and 4 to field officers. Of course, the higher the rank the less chance there is for personal heroism.

The Distinguished Service Medal for the army dates from January, 1918, by executive order and was confirmed by Congress July, 1918. The navy has an identical medal established in 1919. It ranks next to the Medal of Honor and is worn on the left breast to the right of all others. The services need not have been rendered at the front, much less in action, the requirement of great responsibility being the controlling factor. It is our equivalent for the French Legion of Honor. About 1200 of these medals have been awarded, 55 per cent to army officers (including marines serving abroad with the army); 37 per cent to foreign officers; 6 per cent to American and foreign civilians and 2 per cent to U. S. naval officers. The bronze oakleaf cluster is used where a second award is justified.

The Distinguished Service Cross is purely an army decoration and is awarded for "extraordinary acts of heroism in connection with military operations against an armed enemy." Civilians are eligible if they can qualify to the severe rules outlined in the regulations. Bronze oakleaf clusters take the place of the Cross on a second award. Women can receive this decoration if their achievement warrants it. About 5200 crosses were awarded and 95 oakleaf clusters. On this point Colonel Wyllie says:

"Considering the question of rank the observations made with regard to the Medal of Honor are confirmed by this decoration as 72 per cent went to enlisted men, 22 per cent to captains and lieutenants, and only 6 per cent to the higher officers. An analysis of the awards to arms of the service again shows the infantry far ahead of all others, 80 per cent being credited to that branch, then came the Medical Corps with 6 per cent, then the Air Service with 5 per cent, the Artillery 4 per cent, Engineers 3 per cent, the remaining 2 per cent being divided among all other branches."

The Navy Cross was authorized by the same law for those in the naval service and Colonel Wyllie says: "The difference between this and the Distinguished Service Cross of the army should be noted. The army decoration is given only for heroism in war, while the Navy Cross is much broader in scope and in addition to heroism it includes any other distinguished

NAVY UNIFORMS DEMONSTRATE THE SAME TREND TOWARD SIMPLIFICATION AND GREATER UTILITY

Left: Naval uniform as worn during the war. *Center*: The splendor of the old full-dress line uniform. *Right*: The new type of uniform

service, not only in time of war but also in peace, in the theater of hostilities and elsewhere. When given for heroism it is the equivalent of the Distinguished Service Cross of the army. . . . The three naval decorations cover the whole possible gamut of services which should be rewarded; the Medal of Honor being appropriate for the most extraordinary heroism in action, the Distinguished Service Medal for specially distinguished service in a 'duty of great responsibility,' and the Navy Cross for any meritorious service of whatever character, of a lesser degree."

CERTIFICATES OF MERIT, CITATION STARS AND CITATION CERTIFICATES

The certificate of merit was formerly bestowed on privates and non-commissioned officers, but after seventy-one years it was discontinued in July, 1918, and there is nothing which exactly takes its place. Every officer or enlisted man who is cited in orders for gallantry in action under conditions not warranting the award of a Medal of Honor or a Distinguished Service Cross is entitled to wear a silver star on his ribbon. We find many on Victory Medal ribbons. A citation certificate is a reward of merit issued by the Headquarters of the A.E.F. and signed by General Pershing; it was a stop-gap device and they are not now issued but possessors of them are fortunate.

Colonel Wyllie takes up American Service Medals and Badges, but this does not come within the purview of our subtitle. Then follow chapters on the medals and decorations of Great Britain, France, Belgium, Monaco, Portugal, Italy, Eastern Europe, Asia and our neighbors, Cuba and Panama. We have now concluded with the decoration of persons and we come to the decoration of things.

DECORATING THE COLORS

The history of flags goes back to great antiquity and the subject is too extensive to be even touched upon here except that colors are often decorated as a commemoration of deeds as individuals are decorated for services rendered. Colonel Wyllie says: "In the American and British armies each regiment and other independent unit carries two colors, one being the national flag, the other a flag distinctive of that particular organization, called the regimental or organizational color. In France, Italy and Belgium only one color is carried, the national flag, but certain additions are made to it so that it combines the functions of the national and regimental colors in one."

Let us consider the British system first. Their regimental colors follow no particular plan of design. Each regiment has its own characteristic flag which is different in nearly all particulars from any other. The names of all the important battles in which the regiment has taken part are embroidered on this flag. These are equivalent to the service medals awarded to individuals. The British have no decorations for the colors corresponding to personal decorations for specially distinguished services. The French regimental flag has the national tri-color as a foundation. On one side is the inscription "La République Française." with the designation of the regiment. In the upper and lower corners next the staff are laurel wreaths enclosing the regimental number. On the other side of the flag is the inscription "Honneur Patrie," and under it the names of the four most important battles in which the regiment participated. These again correspond to service medals but the number is limited to four, while the British make no limitation as to numbers. But the French system does not end here. Attached to the staff near the spearhead is the *cravate*, and when a regiment is cited in orders for extraordinary services in action the colors are decorated by attaching a Croix de Guerre to this *cravate*. The cross of the Legion of Honor is used instead when it is desired to show exceptional honor to the regiment. Here we have a decoration of the colors in a manner paralleling the award of a personal decoration to an individual, nor is this all. When a regimental color has been decorated twice a *fourragère* in the colors of the Croix de Guerre (green and red) is authorized as a part of the uniform of the organization, to be worn by every man who belongs to it. The *fourragère* is a cord attached to the left shoulder encircling the arm, and hanging from it is a *ferret* (pencil) of bronze. When the color is decorated four times the *fourragère* is changed to one in the color of the the Médaille Militaire (yellow and green) with silver ferrets, and after six decorations a *fourragère* in the color of the Legion of Honor (scarlet) with gold ferrets, is worn by every man in the organization. When the flag has been decorated nine times a double *fourragère* is worn, the green and red being combined with the scarlet *fourragère;* for twelve such decorations the yellow and green is combined with the scarlet and for fifteen a double *fourragère* of scarlet is worn. It should be clearly understood that the *fourragère* is not a decoration of the individual but of the regiment; it is a part of the uniform authorized to commemorate the heroic deeds of the organization, and a man actually wearing it may never have been in any engagement as he may have joined since the war was ended, nevertheless he wears the *fourragère* as a part of his uniform. It is discarded upon transfer to a regiment not entitled to the *fourragère*, except that a man who participated in all the battles for which the regiment was decorated is entitled to wear it as long as he remains in the service, wherever he is assigned.

INSIGNIA

Insignia is a most fascinating subject and we can safely leave Colonel Wyllie's excellent (though brief) treatment of the subject to the reader of the book itself as it is impossible to translate into cold black and white the vivid colors shown in the four plates devoted to shoulder insignia. We have selected for reproduction a picture which is again far afield from Colonel Wyllie's book. This is a decorative blanket embroidered by a patriotic French woman with the U. S. shoulder insignia *she saw* in France and while not complete it is certainly an impressive collection. A distinctive badge for an army corps is not new for we find it in the Civil War, but the designs were worn on the hat and the same was repeated in the Spanish War. The shoulder decorations of the U. S. forces in the recent war was a common-sense way of solving a difficult problem so that men did not "get lost" either by accident or design. The whole thing was surrounded in more or less mystery and was not a device of the War Department, but it was so very efficient and was so well liked and made for discipline that the military authorities were so won over and a difficult problem for General Headquarters was almost automatically solved so the "wild cat" of the Eighty-first Division was the pioneer. All commanding generals of all combat divisions were directed to select at once insignia for their divisions. A riot of invention follows—the alphabet, numerals, geometry, heraldry, history, ethnology, natural history, botany, astronomy, meteorology and even archeology were all laid under contribution. While the designs varied in excellence the animals seemed to be the most popular and we have polar bears, buffaloes, greyhounds, eagles, cocks, etc. The most appropriate was the lizard of the camouflage corps and the most artistic was the classical head on the shoulder insignia of the Army Artillery School. A collection of these devices will be found interesting long after the sting of the war has lost some of its poignancy. The insignia of rank and branch of profession was also considerably changed and augmented by war.

UNIFORMS

Colonel Wyllie does not go into the question of uniforms beyond the insignia and decorations which now form a part of them but it seemed as though the general subject might be rendered even more interesting by including a few pictures showing full-dress uniforms of the army contrasted with the service uniform in all its severity and as we write the regu-

lations allowing "Mufti" to be worn when off duty by all officers has been promulgated except when not on army post or "engaged in athletics." This is a tacit but valuable indication that actually if not technically the war is over. In the navy for a time the florid uniforms gave way to the simple undress uniforms and contrast that of Admiral Dewey with Admiral Sims' but now full-dress uniforms for certain occasions will be obligatory, but even with this the lessons of the war show that results can be obtained without the elaborate shoulder bars and pipings of a generation ago. Simplicity very largely reigns and "Pomp and Circumstance" has been reduced to its lowest terms.

METHODS FOR DETERMINING SOIL ACIDITY

Salts of strong acids with strong bases, of strong acids with weak bases, of weak acids with weak bases, calcium hydroxide, the lowering of the freezing point, the catalysis of esters and the hydrogen electrode are all in use in one or another of the various methods advocated for the determination of soil acidity. The results obtained by the different methods show that the condition of a soil at any time can be considered as its progress toward a constantly changing equilibrium according to the principles of Le Chatelier. It is to be remembered that those metalic elements occurring in ordinary soil stand at the top of the electromotive series of elements and that sodium and potassium compounds are all somewhat soluble; whereas many calcium and magnesium compounds and most iron and aluminum compounds are very sparingly soluble in water.

The entirely different results obtained with different salts, and the large variations in soil acidity recently found by Conner when soils were kept at different moisture contents, make it certain that acid soils usually contain many soluble hydrolytic products which are controlled in amount by the quantity of alkaline earths and alkali metals present in the soil.

Carbon dioxide gas has long been known to cause many chemical changes in silicates and phosphates resulting in increased solubility of the constituents of these substances.

Dr. H. A. Noyes presents, in *Science* for June 10, 1921, the following results obtained in recent investigations where soils in culture pots were treated with carbon dioxide.

1. An "alkaline" sandy soil became acid in reaction in three months' treatment with carbon dioxide gas.
2. The acidity of an acid brown silt loam was increased by treating the soil with carbon dioxide gas.
3. Liming this loam decreased its acidity but not as much as the original "lime requirement" determination (Veitch) indicated. One and one-half times the total lime requirement did not neutralize the soil.
4. Where the soil was limed, limed and phosphated, and limed and treated with dried blood or sodium nitrate, carbon dioxide gas additions to the soil increased the soil acidity.
5. The specific conductivity of extracts obtained on treating the soils with conductivity water showed that the carbon dioxide gas had changed the constitution of the soil. The specific conductivity of the dioxide-treated soils was greater.
6. The acidity of the soils was lowered by extraction with conductivity water and the lowering was greater for those samples which had been subjected to the carbon dioxide treatments. A further evidence that the acidity was due to chemical changes in the soil was that the aluminum and iron in the normal potassium nitrate extracts was effected by the carbon dioxide treatments.
7. The volatile material determination was increased by carbon dioxide treatments, and since this increase could not be accounted for in the determination of total carbon, the carbon dioxide gas must have changed the water of constitution of some of the soil silicates.
8. The composition of the conductivity water extracts from the different soils varied as the fertilizer constituents added would theoretically replace substances known to be present in the soil.
9. The composition of the conductivity extracts from the carbon dioxide treated samples showed that the increased specific conductivity and acidities due to carbon dioxide treatment were associated with substances with low solubility and ionization constants present under conditions where hydrolysis readily took place.

In conclusion Dr. Noyes says: The shifting of the acidity, the chemical changes in the soil and the soil extracts were in accordance with the solubilities of salts of metals high in the electromotive series and their tendencies to hydrolize. The work leads to the conclusion that soil acidity is the resultant of hydrolytic mass action phenomena and thus the application of the exact amount of lime shown by any method cannot be expected to give exact neutrality.

SUN SPOTS AND TERRESTRIAL MAGNETIC STORMS

It has long been known that a close relation exists between sun spots and the irregular magnetic disturbances known as magnetic storms, but no satisfactory reason for this relation has been shown.

The work of Hale and others, at Mt. Wilson, has shown that sun spots are the visible manifestation of tremendous cyclonic disturbances upon the sun. It has also been shown that powerful magnetic fields are produced over large areas in the centers of these cyclonic vortices, which fields are apparently due to convection currents set up by the rotation of negative ions around the storm centers.

It has frequently been shown that magnetic storms have the characteristics which would follow from vortex currents in the earth or in the upper atmosphere. It has been assumed that these currents are due to electrons expelled from the sun and forced into spiral paths by the earth's magnetic field.

The fact that both clockwise and counter-clockwise vortices are shown by magnetic storms in the same regions indicate that their rotational motion is not caused by the earth's magnetic field. Also, it is known that the sun has a magnetic field about 50 times as strong as the earth's field, hence no electrons can be expelled from the sun except in the direction of its magnetic axis, and would not reach the earth.

The diurnal variations in the earth's electrical potential which have been recorded at Palo Alto seem to show that the earth, as well as the sun, is highly electrified, and with negative charge. This gives plausibility to the assumption that the other planets are similarly electrified, and furnishes a theoretical basis for the conclusion, hitherto based upon empirical data, that the periodicity of sun spots depends upon the relative positions of the planets. Reference is made to the evidence furnished by La Rue, Stewart and Loewy that the sun spot area varies with the angular distance between Mercury and Venus and to the fact that the mean sun spot period of a little more than 11 years is closely related to an integral number of revolutions of each of the planets.

Thus: Mercury makes 45 revolutions in 11 years; Venus makes 18 revolutions in 11.08 years; Earth makes 11 revolutions in 11 years; Mars makes 6 revolutions in 11.25 years; Jupiter makes 1 revolution in 11.8 years.

Attention is also called to the fact that the diurnal variation of the N component of terrestrial magnetism has been shown by Chree to be about 70 per cent greater in the four-year period including sunspot maximum than in the corresponding period at sunspot minimum. This phenomenon cannot be due to the sun spots, themselves, since it is shown by the records of days of least magnetic disturbance. From the point of view of the present writer such a variation could be caused by the sun only if the total electric charge of the sun varied periodically with the sunspots. Apparently, both the disturbances in the sun's electric field which gives rise to sun spots and the increase in the diurnal variation of the earth's magnetic field must be due to electrical induction by other charges in the solar system.—Abstract from *The Physical Review*, April, 1921. Article by F. Sanford.

The Individual and the Species*

Insect Experimentation That Throws Light on the Problem of Where to Draw the Line

By Leon Bertin

WHEN we look over the numbers of the *Bulletin de la Société Entymologique de France*, or the reports of any other society engaged in the study of insects, we are struck by the great number of notes bearing such titles as "Description of New Species," "Description of a New Variety," "Classification of a New Geographical Variety of Such and Such an Insect," etc. Among the French fauna alone some thirty new species are thus *created*, so to speak, every year. . . . However, it is allowable to debate the actual value of the *sois-distant* species and varieties to which our amateur entymologists have given new names. Is it not quite possible that in many cases they have mistaken purely individual aberration of character for specific new characters? What would these naturalists think of one of their colleagues who should describe a man as the type of a separate species according to whether his complexion is dark or fair, or whether his nose is aquiline or retroussé. . . . We may remark with regard to this that insects—like most animals indeed—are essentially variable in nature. . . . Take the *Zygenæ*, for instance: moths of a blood-red color. While this is their characteristic hue it is by no means rare to find among them certain individuals with wings of a much paler shade, rather salmon-colored than bright red. Moreover, cases of albinoism, or the paling of color and of melanism, *i.e.*, the deepening of color, are extremely frequent among insects and the cause of this is usually unknown. . . .

However, when we come to the blue-winged cricket (*Ocdipoda casrulescens*) which is quite common in the vicinity of Paris, and two or three specimens of which have been found with yellow wings like those of the Algerian cricket (*Oc. sulphurescens*), it is fair to suppose that this change of color is due to a perfectly natural cause, namely, the climate.

In a certain Brazilian forest a traveling naturalist discovered a definitely circumscribed area in which all of the insects, including flies, butterflies, and wood lice, were red, and another well-defined area in which they were blue. In Ceylon nearly all the native insects are greeu. It would seem that either the food, or the temperature, or the light, must be the factor which produces such a general uniformity of color among all the insects surrounded by the same conditions of life.

Examples of this sort might be multiplied indefinitely, but we shall confine ourselves to a single case, that of the Notonectes studied by Delcourt in 1909. These are water fleas living in ponds and in those portions of water courses where the current is retarded by water plauts. After examiuing 30,000 of these, captured in various parts of France, he came to the conclusion that the 3 species *Notonecta glauca, N. marmorea* and *N. furcata* pass into each other by insensible gradations in southern regions. The spots on the wings of *N. glauca* gradually diminish uutil they entirely disappear in *N. furcata*. In Paris and in the north of France on the contrary *N. furcata* on the one hand and the former two species on the other hand form two groups which are distinctly different with respect both to physiology and to morphology. It is evident from this example that environment is a powerful factor in the variation of animals, since the relations of these 3 species have been so greatly altered by a difference of merely a few degrees of latitude.

Thus mere observation leads us to couclude that living organisms are variable under the influence of the different factors which conditiou their existence (temperature, humidity, light, food, etc.).

While the first method of study in every natural science consists of observation, the second method is that of experiment. Observation suggests the hypotheses which it is the object of experiment to verify. . . . In this article we shall attempt to find out whether the hypothesis that the medium exerts an effect upon all living creatnres is true or false . . . by a study of various classes of experiments.

I. TEMPERATURE EXPERIMENTS

The more humid portions of our woods are frequented in the summer by a butterfly having wings of a black or dark brown color marked by a standing row of white spots. This is known to entomologists as the *Vanessa prorsa*. It lays its eggs at the end of the summer and its caterpillars appear and form chrysalids, from which then issue, after they have survived the rigors of the winter, not the *Vanessa prorsa*, as one might have expected, but a butterfly long known as the *Vanessa levana*, having light-colored wings marked by black spots. The eggs of these develop very rapidly and produce once more the *Vanessa prorsa* having dark wings with light spots, and there is a regular alternation between these generations of spring and of summer. . . . Professor Weissmann, of the University of Fribourg, undertook an experimental study of these alternating generations. He found that the *levana* chrysalids are normally transformed into *V. prorsa*, but that when subjected to cold in an icebox they produce *V. levana*—in other words there ceases to be an alternation of generations. Inversely, the chrysalids produced by the *prorsa* generation, when kept at a high temperature (15 to 40 deg. Cent.) produce finally, instead of the *levana* generation, butterflies of a new sort, *V. porima*, which have large black spots upon their wings and form an intermediate variety between the other two. It is a remarkable fact that this *V. porima* is sometimes found in nature, in the fall of the year when specially favorable conditions of the atmosphere have caused the *prorsa* larvæ to develop very rapidly.

Without dropping the subject of the *Vanessa* butterflies, which have always been popular with the public because of the graceful coutours and brilliant colors of their wings, we may cite some temperature experiments made by Standfuss from 1886 to 1900:

Chrysalids of the small tortoise-shell butterfly, *V. urticae* were reared for a greater or lesser length of time either in an oven kept at a temperature of 40 deg. Cent. or else in au icebox. Under the influence of the heat there were produced butterflies having darker colors than usual and resembling the *ichnusa* variety of Corsica and Sardinia, where the climate is a warm one. Cold, on the contrary, produced the light-colored variety *polaris* found in Scandinavia.

Standfuss also subjected chrysalids of *V. urticae* to "shocks" of cold or heat, *i.e.*, to very low temperatures —8 deg. Cent.) or very high ones (45 deg. Cent.) for a few hours each day. Very pronounced changes in color were thus produced . . . these were very irregular . . . and too complex to be fully explained in the present state of our knowledge.

The special interest taken by Standfuss in these variations among the *Vanessa* which haunt nettles was related to his studies of the inheritance of acquired characteristics. . . . He selected males and females which had been rendered abnormal by the effect of cold. 2000 caterpillars were obtained from the pairing of 8 females and 30 males. But various maladies, such as are almost inevitable in the rearing of a large number of lepidoptera, decimated the group. Only 500 caterpillars succeeded in becoming successfully transformed into chrysalids and from these 200 butterflies were obtained. But among these 196 were normal while 4 (all males) were ab-

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), for March 19 and 26, and April 2, 1921.

normal in the direction of the parent type. This experiment therefore is very far from being favorable to the hypothesis that acquired characters may be transmitted by heredity.

Another entymologist of Zurich, Fischer, made use for his experiments, in place of *Vanessa*, of a night moth having a very brilliant sheen; this butterfly which is red marked with large, black spots is known to collectors under the name of *Arctia caja*. His experiments made in 1899 gave the following results: 135 caterpillars were raised in a state of captivity, 102 entered the state of chrysalids and were divided into two lots, 54 in one and 48 in the other. The first lot were kept at the ordinary temperature and the second lot was subjected to an intermittent temperature of 8 deg. Cent. below zero. While all the butterflies issuing from the first lot of chrysalids were normal in color, 41 out of the second lot exhibited a considerable increase of size in the black spots upon their wings.

In a complementary experiment with respect to heredity, males and females of the *Arctia caja* chosen among those which were most melanic in character were paired and the resulting eggs were developed in cages of the ordinary temperature. All the butterflies obtained except a very few were normal, thus furnishing a new proof of the non-heredity of the acquired characteristics—*at any rate under the conditions of the experiment.*

Following the experiments of Fischer in point of time, are those of the Geneva scientist, Pictet (A. Pictet *Mém. Soc. Phys. et Hist. Nat.*, Geneva, 1912, Vol. 37). These constitute an investigation of enormous extent, relating to various species of butterflies which were submitted to an elevation or a lowering of the temperature. These experiments, together with those of Pictet's predecessors enable us to formulate certain general laws with respect to the variation of insects.

From 1904 to 1911 several thousand chrysalids of the *V. urticae*, caught in the vicinity of Geneva, were subjected to high temperatures. Each lot was kept for a definite number of hours at a temperature of 40 to 45 deg. Cent. The phenomena first observed consisted in the liberal appearance of albino and melanic forms. The varieties *V. ichnusa* and *V. polaris* obtained by Standfuss through the contrary effects of heat and of cold were in this case both obtained by the action of heat. Furthermore, the changes of color were produced in only a small number of the butterflies. About half of the chrysalids were in no way influenced by the action of the heat. We may add that a microscopic examination revealed that the super-coloration and the decoloration of the wings were due to a greater or less abundance of the *ordinary* pigment. As a matter of fact the melanism is due to the circumstance that the normal coloring mater is produced in greater quantities. The diminished size of the scales charged with pigment is an added cause of the albinoism.

1. By subjecting Vanessa chrysalis to variations of temperature Weissmann, Standfuss and Pictet have succeeded in obtaining artificially, both geographical races (the *ichnusa* and the *polaris varieties* of *V. urticæ* and seasonal forms (*V. prorse, levana, porima*). It is therefore, highly probable that the same factors, which are climatic in character, act in the same way in a state of nature.

2. *Not all chrysalids are equally sensitive to variations in the external medium.* There may be a *critical point, i.e.*, a precise moment in the evolution of the nymph at which the temperature is effective in producing variations in morphology.

3. All the changes of color obtained by experimental variations of temperature may be reduced to the intensification or the attenuation of the color—in other words to *melanism* and to *albinoism*. There is merely an increase in size or a contraction of certain spots upon the wings—no new color ever makes its appearance.

This *law of variations by means of the melanism or the albinoism of certain portions* was first formulated by Overthur in 1893. It tends to diminish the importance previously ascribed to variations of color in insects.

4. *The same variations can be produced either by a rise or by a fall of temperature. Reciprocally two opposite variations—a supercoloration and a decoloration—may be due to the same cause.*

Professor Tower's Experiments.—Apropos of this we may cite the extensive experiments covering some ten years made by Professor Tower of the University of Chicago, upon the American potato bug (*Leptinotarsa decemlinetta*). The color and the marking of the different parts of the body are here very variable among individuals of the same collection. . . . Those species which are most widely distributed geographically were found to be most variable, since the differences of the environment with respect to temperature, light, humidity, and food varied more widely than in more restricted areas. . . . Thousands of larvæ reared in cages at a temperature several degrees higher or lower than that of the surrounding air, produced more or less modified adult insects. . . . Whenever the change in the degree of heat was slight, whether higher or lower, melanism occurred, while albinoism was produced when this difference was of considerable amount. Professor Tower says: "Among the thousands of variations of color which I have produced none displayed the slightest sign of being permanent in successive generations or in hybrids and they ceased to be capable of selection *as soon as the cause which had produced them disappeared.*" . . .

II. Experiments in Humidity

The English colonial naturalist, Marshall, describes the existence in the Transvaal of the two forms *octavia* and *sesamus* of the same butterfly of the genus *Precis*, the former having salmon-covered wings adorned with black spots and frequenting, during the *humid season* (corresponding to our winter), high and treeless localities. The *sesamus* form, on the contrary, has red wings marked with blue spots and appears in great abundance during the *dry season* in woods and forests or near human dwellings. The eggs of one of these forms produce adults of the other and vice versa. Other investigators working with a different subject (*Melanitis leda*, etc.) have succeeded in producing at will the dry season forms and the humid season forms by rearing the chrysalid in a dry or humid atmosphere. . . .

Apropos of this Tower found in his potato bug experiments that an increase or decrease of the amount of moisture in the atmosphere produced precisely the same variation as the changes of temperature—namely, first melanism and next albinoism. . . .

5. To these four laws we must now add a fifth which is of the greatest possible importance, namely; the same change of color is capable of being produced in one direction or in the other by a variation in the degree of humidity as well as by a variation in the degree of temperature. *In other words, the different factors of the environment do not exhibit any specificity of action.*

III. Experiments with Light

Adult insects rarely exhibit as great a response to light as do their caterpillars or chrysalids. Maria von Linden found only a slight variation in size in certain butterflies whose larvæ had been reared in boxes made of glass of different colors. Such experiments are of interest merely as confirming the second law formulated by Pictet, namely, that there is a *given moment*, in other words there is a *definite critical point* in the life of an insect when it is necessary for the external factor to operate in order that a variation in form may be produced.

As a matter of fact it is probable that the reason why most of the experiments with light undertaken by Weissmann, Standfuss, Fischer, Blanchard, Cholodkovsky, etc., have not given satisfactory results is because these authors exposed to the colors of the solar light any sort of caterpillars without regard to the critical point referred to above.

When a caterpillar of the *Vanessa urticæ* is about to become

a chrysalid it descends from the nettle upon which it has been feeding, finds a suitable location and then hangs head downward until the skin splits and falls off, leaving behind the grotesque chrysalid; the immobile period just preceding the dropping of the skin is called by Poulton Stage II.

If caterpillars are placed, in this stage—*and in no other*—in a glass tube covered with white paper, or better still gilt paper, the chrysalids which shortly appear are unusually beautiful, looking as if they had been covered with gold leaf instead of being black, as they are in nature. When gilt paper is employed more than 85 per cent of the chrysalids are golden in hue. Moreover, the 15 per cent which remained dark must have been in the shadow of the others in the same tube.

Was this result due to an actual color photography? Poulton has proved that the nervous system of the caterpillar is at least partly responsible for the effect. He suspended a caterpillar in this stage in a glass box covered with black paper at the top and gilt paper at the bottom, or vice versa. The chrysalid which appeared was not parti-colored in black and gold, as might have been expected, but all one color, that of the light to which the greater part of its body had been exposed. Evidently the nervous system had operated to render the color uniform. . . . The experiment resulted in the same manner when the eyes of the caterpillar were covered with an opaque varnish, hence vision played no part.

IV. EXPERIMENTS IN FEEDING

Since development is the immediate effect of feeding living creatures, it is *a priori* evident that any modification in the amount or quality of the food must be an important source of variations in form. . . .

In defining any given species of animal we take into account, *inter alia*, the dimensions, since the size varies within but narrow limits among either individuals or generations. Size may be regarded as typical of the characteristics termed *fluctuating*. . . . While both giants and dwarfs are produced at times, they leave no descendants. . . .

This would cause us to expect that efforts to alter the size would be futile. But in 1903 Kellogg and Bell succeeded in producing dwarf races of silk-worms by feeding them upon lettuce instead of the more nourishing mulberry leaves generally fed to them. They remained dwarfs for successive generations even when restored finally to the mulberry leaf diet.

CHANGES OF COLOR PRODUCED BY FEEDING

Color changes due to food are much more marked than change of size. . . . In 1896 Standfuss obtained butterflies of the *Callimorpha dominula* with yellow wings instead of the normal red by giving the caterpillars a diet of leaves which had been soaked in a solution of ordinary salt. This result accords with the observation that specimens of this species reared upon the seacoast often have posterior wings of a yellowish hue.

Poulton divided a single deposit of *Tryphaena pronuba* eggs into two lots, feeding the first lot with complete cabbage leaves and the second lot with those parts of the leaf which entirely lack chlorophyll. The first soon became green or brown as in nature, while the second remained colorless. While this suggests that the color of the caterpillars is due to the green coloring matter of the cabbage, it remains to prove this by chemistry and the microscope.

Most remarkable of all in this line are the experiments made by Pictet. . . . *Ocneriâ dispar* or *Lymantria d.*, or *Liparis d.*—the names are synonymous—is an ugly dark brown night moth often called Zig-Zag by farmers because of the broken black lines which adorn its upper wings. The females bear the same marks on a white ground, and are also larger than the males. Normally they live on the oak and the birch. . . . Pictet obtained the following results on changing the food: When fed on the leaves of the walnut the males were altered as follows: 1. The size was reduced. 2. The color was pale, ranging from brown to yellow and even to white. 3. There was an attenuation, or even an entire disappearance, of the zig-zag marks. All of these acquired characters probably indicate a degeneration of the race. If the same diet is continued they are accentuated in later generations, but attenuated when the normal diet is returned to. We shall see later what this suggests with respect to the heredity of acquired characteristics.

When fed on sainfoin or "French grass" the caterpillars of this species produce butterflies with still different acquired characters. . . . If we give oak leaves to the first generation, walnut leaves to the second, and sainfoin to the third we obtain "harlequin" butterflies, of the three colors superposed. . . .

In this species, and in general in all the Bombzeides the caterpillars from which males are produced differ in aspect from the other sex. In other words sexual dimorphism exists even in the larval state. But when they are fed upon walnut leaves and are therefore ill-nourished all of the caterpillars look like males, although they produce both sexes in the usual proportions. But when fed with the much richer nutriment of the sainfoin, all of the caterpillars exhibited the secondary characters of females, although they produced a constant proportion of the two sexes as in the preceding case and as in nature. These facts tend to establish the independence of sex and secondary sexual characters. . . .

Pursuing the same idea Pictet came very near accomplishing a transformation of the *Vanessa polychloros* into the *V. urticæ* by feeding the caterpillars of the first species upon nettle leaves.

In 1907 Marchal made analogous experiments with the cochineal insect of the acacia. This plant was introduced from America into Europe in the 17th century. . . . Until 1881 it did not suffer from attacks by cochineal insects either in its native or acquired home, but in that year the European trees were attacked by a species of cochineal insects which was termed a new species by a specialist of the period and called the *Lecanium robiniarum*. Where did this come from?

Marchal answers this question by declaring that this new species is due to the transformation of the peach tree cochineal (*Lecanium corni*). The newly hatched larvæ of *L. corni* were placed upon the limb of a young acacia. They suspended themselves to the leaves and in the fall a number of them attached themselves to the bark in order to pass the winter. The others died in large numbers. Those which were attached to the wood appeared the next spring in the form of *L. robiniarum*, recognizable by their larger size and their darker color. Thus the passage from one species to another was accomplished in a single generation. Intermediates in nature between *L. corni* and *L. robiniarum* are the *L. vini* and *L. wistariæ*. Thus there is a different sort of cochineal insect for each sort of nutritious sap. This suggests states of equilibrium in chemical compounds governed by temperature and pressure.

V. VARIOUS EXPERIMENTS

The electric state of the atmosphere forms part of the conditions of life which control terrestrial organisms. It is not surprising that it should modify butterflies at certain periods of their existence. It has been noted, for example, that those specimens of *Arctia caja* which issue from the chrysalid in stormy weather often exhibit anomalies of color. Other chrysalids, upon being submitted to discharges from an induction coil are transformed into melanic butterflies. . . . Professor Mercier of Caen has reported a curious example of the effects of the ordinary agents of modification, pressure, contact, shock. The pupæ of a small fly (*Fucellia mantima*) were placed in narrow glass tubes closed with stoppers of cotton-wool. The flies which were born could not turn around and sought to escape by thrusting the head against the stopper or the walls of the tube. The frontal vesicle thus alternately swells and contracts while still soft. But suddenly the chitin becomes rigid so that the flies retain thereafter a horn between the eyes. . . . These are experimental but similarly

horned flies have been found in nature. This experiment has extensive implications:

1. It shows that young insects have malleable figments which can be affected by external mechanical factors. 2. If we suppose several successive generations to be born within similar narrow glass tubes, all of them evidently would exhibit the frontal horn. This horn would be, in fact, acquired anew in each generation. Here we would have then a simulation of heredity, but not true heredity. . . .

Let us now consider the Phasmas, those large orthopterous insects which so closely resemble the twigs of trees, *e.g.*, the *Bacillus gallicus* of the south of France. Their strange aspect is due to the fact that the femurs are so curved as to exactly fit the head, thus forming a straight line with the body. These peculiar curves of the legs are considered specific characters by entomologists, so that one would naturally believe that they are hereditary. This is not the case, however. The curve is imparted at the moment when the insect issues from the egg. At that time the femurs are still soft and are pressed tightly against the head, so that they adapt themselves mechanically to the contour of the latter. For this reason all of the phasmas exhibit the same curves of the femur, merely because they experience the same difficulties in escaping from the egg. Here we see that *the exact repetition of identical conditions of development may take the place of heredity in the determination of the fixed characteristic of a species.*

Let us now consider such questions as the following: What is the cause of the lack of wings, *i.e.*, apterism in certain insects? Why do certain others bear their young alive? etc.

1. *Lack of Wings*—We may recall that Darwin, Wallace, and others have sought to explain the lack of wings by the famous law of natural selection.

In certain cases this lack has been ascribed to a parasitic or sedentary habit (fleas, bed bugs and lice; the Melophages of the fleece of sheep, etc.).

The only experimental work of value along this line has been done by Dewitz and certain American scientists.

Dewitz procured insects with wings reduced to nil by putting the nests of wasps (*Polistes gallicus*) in an icebox; he also made similar experiments with the very young larvæ of the common blue fly (*Calliphora vomitoria*). This experiment agrees with the curious discovery of a wingless fly (*Belgica antarctica*) in the polar region by the Belgian Antarctic expedition. The pupa of this fly possesses wings which are atrophied in the adult, apparently because of the severe cold.

The American savants referred to above sought to discover why winged generations of plant lice, which are ordinarily apterous, appear in the autumn. They planted a rose stalk covered with the young lice in sand watered with various solutions containing minerals or sugar which the lice imbibed along with the sap. Some solutions were found to prevent the forming of wings while others favored this (the sugar solutions). This is particularly instructive when we recall that at the approach of winter plants transform their reserves of starch into sugar. In this case the cold acts upon the lice indirectly through the production of sugar in the sap instead of directly as we must assume it to have done in the Dewitz experiment.

2. *Viviparous Insects.*—Some insects produce their young in a more or less advanced stage of development. It used to be thought that this was due to simple factors such as a high temperature or very rich food (especially in the case of blood-sucking insects. It was thought that the cattle fly (*Musca corvina*) was oviparous in northern Russia and viviparous in the south. But the Russian entomologist Portchinsky, who had stated this to be the fact, later found it to be an error. There are really two distinct species, and in Central Russia both are found feeding upon the same food.

In 1840 von Siebold noted certain facts about the blue meat fly which were confirmed by Guyénot in his experiments with the vinegar fly (*Drosophila ampelophila*) in 1908-1914. . . . He found that if the *life* conditions (food, temperature) of a female vinegar fly be changed in *any manner whatever* when the insect is about to deposit its eggs the function will be retarded for a longer or shorter time. If a female which has been reared upon beer yeast is moved suddenly when about to lay its eggs into a fresh tube containing potato or carrot it becomes viviparous instead of oviparous. The retention of the eggs is so accentuated that they hatch within the mother's uterus. In this case the viviparity is due to insufficient food—or perhaps merely to the change of tube. It is impossible not to conclude that viviparity in insects is an extremely complicated phenomenon.

VI. CONCLUSIONS

The problem of the influence of environment upon living creatures is one of the most hotly debated questions in modern biology. During the last 50 years a good many experiments have been made upon different animals to see whether changes in food, temperature, humidity, etc., can produce hereditary or temporary alterations. Insects of different kinds have formed the subject of many of these experiments.

Some experimental variations are in accord with those observed in nature. This renders them important since they enable us to explain: 1. Geographic races. 2. Seasonal forms. 3. Certain forms very closely adapted to given conditions of existence.

However most of the changes in form due to changes in food, temperature and humidity appear to be of minor importance, as for example: 1. Changes of color producing melanism or albinoism. The same pigment is increased or diminished without undergoing a chemical change. The gamut of variation is limited to the following colors: white, yellow, red, brown, black.

2. The same variation may be produced by any factor whatever, rise or fall in humidity, etc. Thus the disappearance of the blue "half-moons" of the nettle butterfly through an extension of the black border of the wings may be due to an excitation which may be produced by heat, humidity, light, electricity, or by rotation for 5 minutes a day during the nymphal period. Weissmann carried upon a railroad journey some caterpillars of the summer generation of the *Pieris napi* and obtained from them the winter generation just as if he had put them in an icebox.

3. Insects subjected to experiment have a high rate of mortality—many of the animals exhibiting pathological changes.

This last observation emphasizes the great interest attached to the experiments of Guyénot with respect to aseptic life and the development of the organism (*Drosophila amelophila*) in function of the environment.

A number of scientists, especially in America, studied these same vinegar flies before Guyénot. The eyes became white, pink, red, or orange with astounding facility. The wings were rudimentary, truncated, beaded, etc. The innervation of the wings underwent unexpected changes. But while the effect of environment upon vinegar flies has never been denied it remained for Guyénot to devise an experimental method strictly enough controlled to demonstrate it. . . . No experimental study of variation can carry scientific conviction unless there is an absolutely accurate knowledge of the milieu in which the insects live. . . .

Guyénot's method consists of *aseptic rearing.* The flies are kept entirely free throughout their lives from microbes and other parasites which might interfere with the accuracy of the experiments. The ordinary unsanitary cages are replaced by sterilized vials and tubes. The food (yeast, potato, carrot) is sterilized by heat, or better, consists of artificial substitutes whose chemical composition is exactly known. The atmospheric conditions are rendered absolutely stable. . . . This principle of aseptic rearing in animals which are subjected to experiment ought to have a universal application, since it is the *sine qua non* in the experimental study of variations.

The Infancy of Illuminating Gas

How the Original Discovery Was Made by Murdock and How He Brought It Into Use

By Ralph Howard

PART I.

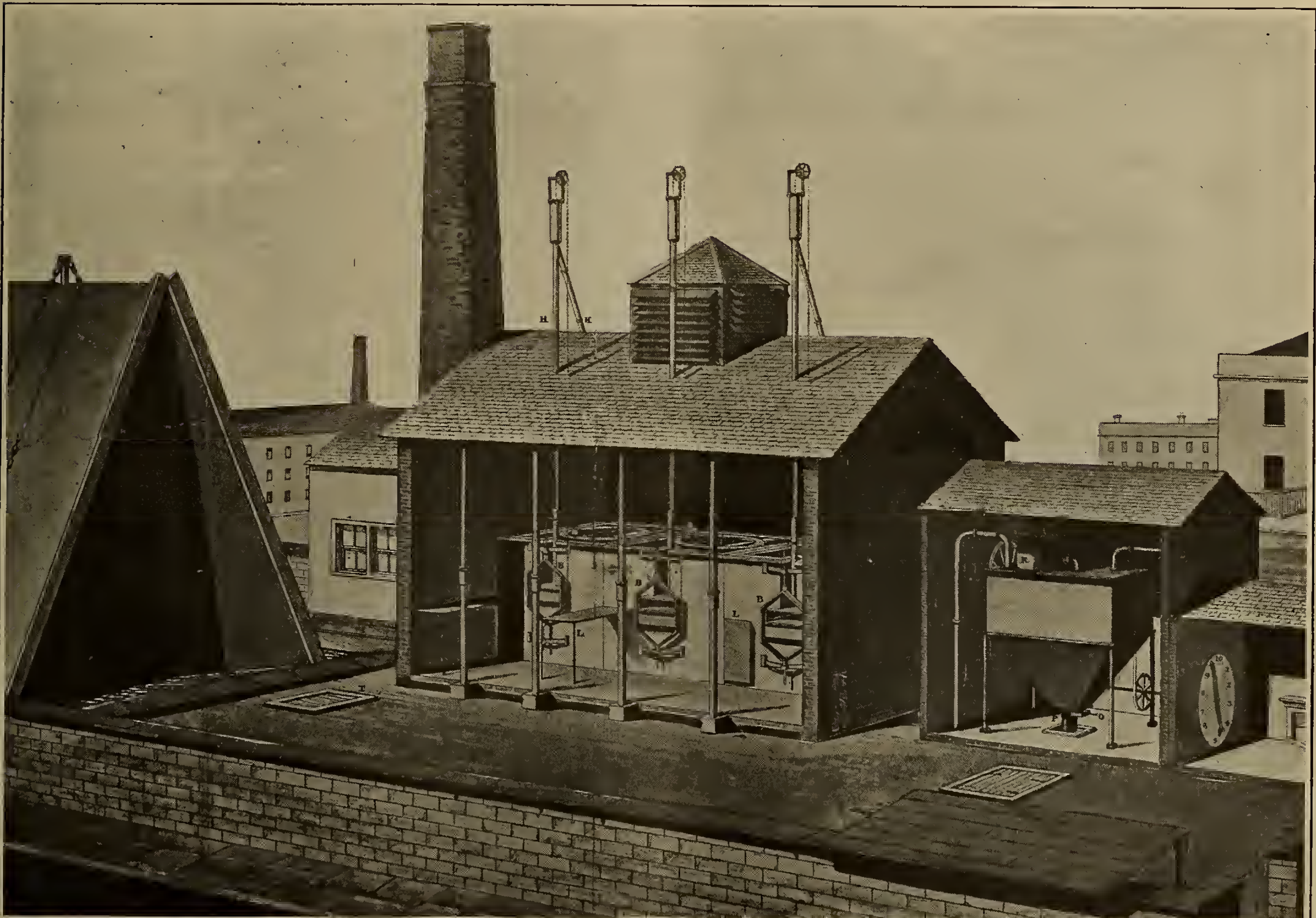
MR. MURDOCH'S PAPER

AN English firm of scientific booksellers recently catalogued two very important items relative to the early history of gas manufacture, including Murdoch's original paper, read before the Royal Society February 25th, 1808. This is the earliest practical essay on the subject and was awarded the Rumford gold medal. The other item is a technical treatise on coal gas, dated 1819, written by Frederick Accum, "operative chemist." We were fortunate enough to secure both of these items, and we can now give our readers one of the most interesting insights in the early history of a great industry which has done so much for the human race. We can begin this résumé most appropriately by quoting William Murdoch's paper referred to. The title was "An Account of the Application of the Gas from Coal to Economical Purpose. By Mr. William Murdoch. Communicated by the Right Hon. Sir Joseph Banks, Bart. K.B.P.R.S."; and Mr. Murdoch's text follows:

"The facts and results intended to be communicated in this paper are founded upon observations made during the present winter, at the cotton manufactory of Messrs. Philips and Lee at Manchester, where the light obtained by the combustion of the gas from coal is used upon a very large scale; the apparatus for its production and application having been prepared by me at the works of Messrs. Boulton, Watt, and Co., at Soho.

"It is not my intention, in the present paper, to enter into a particular description of the apparatus employed for producing the gas; but I may observe generally, that the coal is distilled in large iron retorts, which during the winter season are kept constantly at work, except during the intervals of charging; and that the gas, as it rises from them, is conveyed by iron pipes into large reservoirs, or gasometers, where it is washed and purified, previous to its being conveyed through other pipes, ralled mains, to the mill. [The ultimate consumer in this instance.] These mains branch off into a variety of ramifications (forming a total length of several miles), and diminish in size, as the quantity of gas required to be passed through them becomes less. The burners, where the gas is consumed, are connected with the above mains, by short tubes, each of which is furnished with a cock to regulate the admission of the gas to each burner, and to shut it totally off when requisite. This latter operation may likewise be instantaneously performed, throughout the whole of the burners in each room, by turning a cock, with which each main is provided, near its entrance into the room.

"The burners are of two kinds: the one is upon the principle of the Argand lamp, and resembles it in appearance; the other is a small curved tube with a conical end, having three circular apertures or perforations, of about a thirtieth of an inch in diameter, one at the point of the cone, and two lateral ones, through which the gas issues, forming three divergent jets of



AN EARLY GAS PLANT, SHOWING, FROM LEFT TO RIGHT, THE COLLAPSING GASOMETER, THE RETORT HOUSE, THE PURIFYING HOUSE, AND THE OFFICE AND METER ROOM

flame, somewhat like a fleur-de-lis. The shape and general appearance of this tube has procured it among the workmen, the name of the cockspur burner.

"The number of burners employed in all the buildings [of the Manchester mill] amounts to 271 Argands, and 633 cockspurs; each of the former giving a light equal to that of four candles of the description above mentioned; and each of the latter, a light equal to two and a quarter of the same candles; making therefore the total of the gas light a little more than equal to that of 2500 candles. When thus regulated, the whole of the above burners require an hourly supply of 1250 cubic feet of the gas produced from cannel coal; the superior quality and quantity of the gas produced from that material having given it a decided preference in this situation, over every other coal, notwithstanding its higher price."

Condensing Mr. Murdoch's text here, it appears that the consumption of gas at the Philips' and Lee's mill was 2500 cubic feet of gas a day. In 313 working days 110 tons of cannel coal were used, costing £125. The by-product was reckoned with even in those days, for we find 70 tons of "good coak" remaining which was sold for £93, therefore the total expense for coal was only £32. Mr. Murdoch says:

"The quantity of aqueous fluid which came over in the course of the observations which I am now giving an account of was not exactly ascertained, from some springs having got into the reservoir; and as it has not been yet applied to any useful purpose I may omit further notice of it in this statement."

If he had only known the value of the by-products, he would not have referred so lightly to this. He estimated that the total cost of lighting by gas of this factory was £650, while for tallow candles the expense would have been £3000. Here the first great victory for gas was scored. Mr. Lee's house nearby was also "brilliantly illuminated." So we have the first case of domestic lighting. Our authority then goes on to describe his discovery of illuminating gas.

"It is now nearly sixteen years, since, in a course of experiments I was making at Redruth in Cornwall, upon the quantities and qualities of the gases produced by distillation from different mineral and vegetable substances, I was induced by some observations I had previously made upon the burning of coal, to try the combustible property of the gases produced from it, as well as from peat, wood and other inflammable substances. And being struck with the great quantities of gas which they afforded, as well as with the brilliancy of the light, and the facility of its production, I instituted several experiments with a view of ascertaining the cost at which it might be obtained, compared with that of equal quantities of light yielded by oils and tallow.

"My apparatus consisted of an iron retort, with tinned copper and iron tubes through which the gas was conducted to a considerable distance; and there, as well as at intermediate points, was burned through apertures of varied forms and dimensions. The experiments were made upon coal of different qualities, which I procured from distant parts of the kingdom, for the purpose of ascertaining which would give the most economical results. The gas was also washed with water and other means were employed to purify it.

"In the year 1798 I removed from Cornwall to Messrs. Boulton, Watt and Co.'s works for the manufactory of steam engines at the Soho Foundry, and there I constructed an apparatus upon a larger scale, which during many successive nights was applied to the lighting of their principal building, and various new methods were practised, of washing and purifying the gas.

"These experiments were continued with some interruptions until the peace of 1802, when a public display of this light was made by me in the illumination of Mr. Boulton's manufactory at Soho, upon that occasion.

"Since that period, I have, under the sanction of Messrs. Boulton, Watt and Co., extended the apparatus at Soho Foundry, so as to give light to all the principal shops, where it is in regular use, to the exclusion of other artificial light; but I have preferred giving the results from Messrs. Philips' and Lee's apparatus, both on account of its greater extent, and the greater uniformity of the lights, which rendered the comparison with candles less difficult.

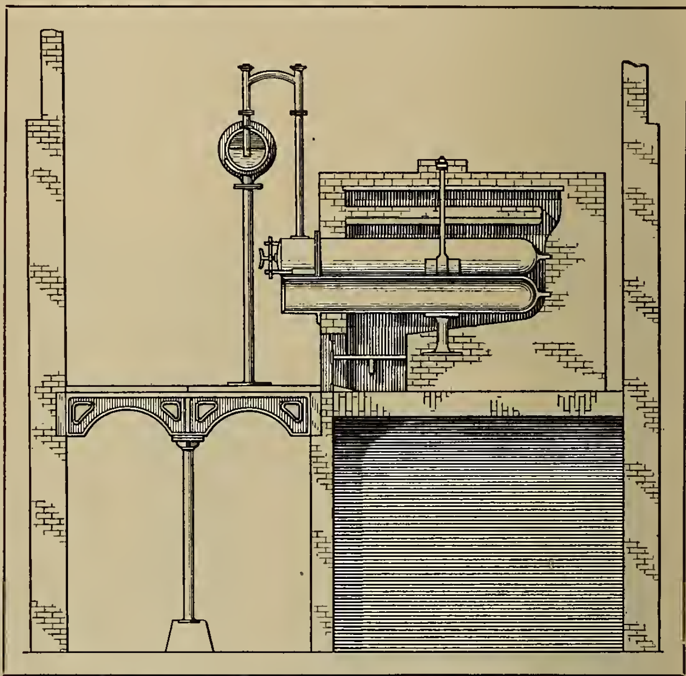
"At the time I commenced my experiments, I was certainly unacquainted with the circumstance of the gas from coal having been observed by others to be capable of combustion; but I am since informed, that the current of gas escaping from Lord Dundonald's tar ovens had been frequently fired; and I find that Dr. Clayton, in a Paper in Volume XLI. of the Transactions of the Royal Society, so long ago as the year 1739, gave an account of some observations and experiments made by him, which clearly manifest his knowledge of the inflammable property of the gas, which he denominates "the spirit of coals;" but the idea of applying it as an economical substitute for oils and tallow does not appear to have occurred to this gentleman, and I believe I may, without presuming too much, claim both the first idea of applying, and the first actual application of this gas to economical purposes."

PART II.

FURTHER HISTORY OF GAS LIGHTING

Frederick Accum, the author of the very excellent treatise on gas manufacture (for the time) appears to have been identified with the industry almost from its inception. He says:

"Capital, often wanting even in this opulent country for undertakings of magnitude, came to the promotion of the new art of procuring and distributing light in overflowing abundance; and already ere many years are elapsed, such has been the rapidity with which the gas light illumination has advanced that there is not a city and scarcely a town of any note in Great Britain, in which the art of lighting by means of gas has not been carried into effect, or in which active measures are not in progress, to participate in the benefit of this important discovery."



AN EARLY FORM OF RETORT FOR GAS-MAKING

He was also familiar with other sources of gas than coal, for we find a little farther on the following:

"I have added an account of the manufacture of carburetted hydrogen gas, from coal tar, vegetable tar, and oil, with such other observations as may enable the reader to form a proper estimate of the comparative advantage of manufacturing gas from oil, or tar, under certain circumstances. I have here also given an account of the manufacture of carbonate of ammonia, as now practiced, from the ammoniacal liquor obtained in the gas light process, and of the manufacture of other saleable

products obtainable from coal, namely, pitch, coal tar, and oil."

At the time he wrote there were 51,000 gas lights in London alone, so we may consider that the industry was firmly intrenched in 1919. His description of the value of gas is naïve. He says:

"It must be difficult for a person wholly unacquainted with this art, to imagine with what facility and neatness gas lights are managed. The gas being collected in a reservoir, is conveyed by means of tubes, which branch out into smaller ramifications, until they terminate at the places where the lights are wanted. The extremities of the branching tubes are furnished with burners, having small apertures out of which the gas issues with a certain velocity corresponding to its degree of pressure. Near the termination of each tube there is a stopcock, or valve, upon turning which when light is required, the gas instantly flows out in an equable stream. *There is no noise at the opening of the valve, no disturbance in the transparency of the atmosphere;* the gas instantly bursts on the approach of a lighted taper into a peculiarly brilliant, soft and beautiful flame; it requires no trimming or snuffing to keep the flame of an equal brightness. Like the light of the sun itself, it only makes itself known by the benefit and pleasure it affords.

"The gas flame is entirely free from smell. The gas itself has a disagreeable odor before it is burnt, and so has the vapor of wax, tallow and oil as it comes from a candle or lamp newly blown out. This concession proves nothing against the flame of gas, which is perfectly inodorous.

"The gas-light flame is perfectly steady; a benefit which persons accustomed to read or write by candle-light are particularly capable of appreciating. With the other modes of illumination we have never the light of the same intensity for two minutes together, independent of that unpleasant dancing, unsteady flame which is so harassing to the sight.

"The saving of labor connected with the employment of gas-light may seem on a small scale to be trifling; but when it is considered that in large manufactories it is not unusual to find several persons employed for no other purpose than trimming the lamps or setting and snuffing the candles of the establishment, the advantage gained on this head by the use of a species of light which require no sort of attention whatever, cannot but appear very considerable."

The use of gas for purposes other than illumination were evidently well known, for he says:

"Numerous applications of gas, as a source of heat for airing rooms, and other purposes, have already been adopted. It is used in kitchens for keeping meat warm, and for boiling water, in store rooms, in picture galleries, in libraries, for maintaining them at an equal temperature. By copper-plate printers, it is used for warming their plates, and by jewelers and other artists, for soldering."

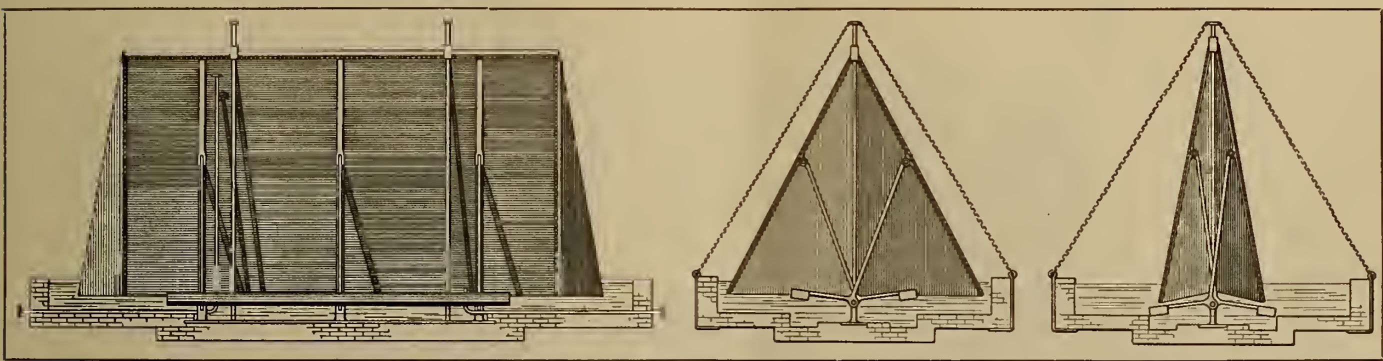
He then goes on to describe the by-products, the coke (which has by this time been spelled in the modern style), tar and ammonia, for of course anilines were not thought of in those days. He cautions all persons not to erect their own plants unless the expense for lighting exceeds 40 pounds sterling. He also suggests that the residents of a street or district club together and build a plant.

The technical descriptions of the gas generating plants are interesting, and the beautiful colored plates rank high in the early history of technical literature. We illustrate two of the plates which give an idea of the processes required. Retorts of all sizes and shapes were adopted, including semi-cylindrical retorts somewhat of the shape we now use, with covers rendered air and gas-tight by a lute, and horizontal rotary retorts, which appeared about 1816, having been invented or at least endorsed by a man named Clegg. One of our engravings show the installation at the Royal Mint of this rotary retort.

RETORTS

The horizontal rotary retorts at the Royal Mint are hollow cylinders, eight feet six inches in diameter and 15 inches high arched a little at the top. They are made of wrought-iron plates, half an inch thick, riveted together in the manner of a steam-engine boiler.

Through the center of the retort passes perpendicularly an iron shaft as shown in the section of the retort. The lower extremity of the shaft revolves upon the bottom of the retort, in a cup-shaped cavity, while its upper extremity passes through the roof of the retort, where the latter is made air-tight by means of a pipe, closed at the top and surrounding the shaft, and hence the shaft must always preserve its center.



EARLY COLLAPSING GASOMETER, IN SIDE VIEW, AND IN END VIEW BOTH INFLATED AND EMPTY

To the lower extremity of the shaft is keyed a box or center piece (technically called a rose center). From this shaft radiate twelve wrought-iron arms, fixed in sockets made in the box. These arms are elevated three inches above the bottom of the retort, and extend to nearly within its whole inner circumference. They are wedge-shaped, and their greatest diameter is at right angles to the base of the retort, so that the weight of the arms rests on the axis. They are intersected by two concentric rings. Between the arms are placed twelve shallow iron trays or boxes, destined to contain the coal from which the gas is to be obtained. They are formed to the segment of a circle, hence the whole series of them when arranged in the retort, exhibits a shallow circular tray, which, when motion is given to the shaft, may be made to revolve within the retort. It will be obvious, that by motion of the shaft, any number of trays or coal-boxes can readily be brought from the coldest, into the hottest, and from the hottest into the coldest part of the retort.

It would be interesting to know why these retorts were never used in later times. The gas was purified by what is known as the "lime machine."

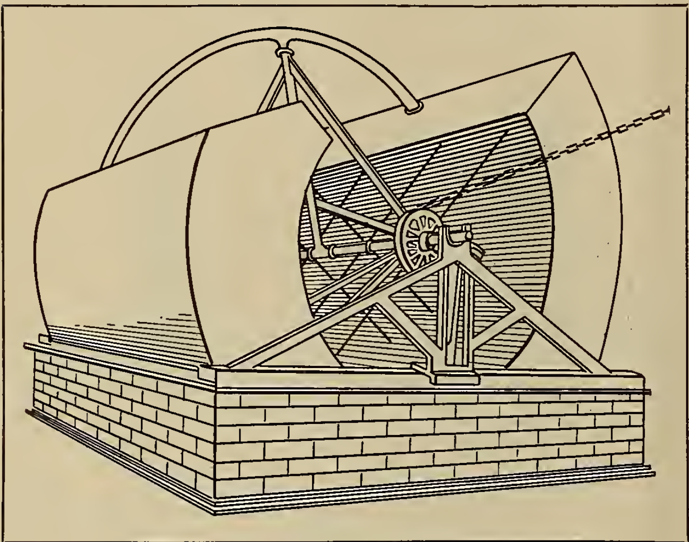
PURIFICATION

"In the lime-machine the gas was made to pass in the apparatus, through passages which could not be guarded from being stopped up in the course of time by the concretion of a quantity of carbonate and hydro-sulphuret of lime, formed during the purification of the gas, so that when the stoppage occurred,

a prodigious pressure was produced in the machine, in consequence of which it was either found impossible to keep the distillatory apparatus air-tight, or if this was accomplished, a great part of the gas was forced through the purifying apparatus without coming in contact with the lime, by driving the column of mixture of lime and water before it, and of course without being rendered fit for use, previous to its passing into the gas reservoir. This effect was unavoidable without the precaution of employing a very dilute mixture of quick-lime and water. Numerous instances have also occurred where from the increased pressure which the gas exerted in the lime apparatus the tar from the hydraulic main was driven up with a prodigious force through the dip pipe, into the retort when the retort was opened, where it took fire to the imminent danger of the whole establishment."

THE GAS HOLDER

"The name of gas holder, or, as it is improperly called, 'gasometer,' is given to the vessel employed for collecting the gas and storing it up for use. In the principle and construction of this part of the gas light machinery, peculiarly valuable improvements have of late been made. They have contributed to lessen the expense of the apparatus so much that a reservoir for storing up any quantity of gas may now be furnished for



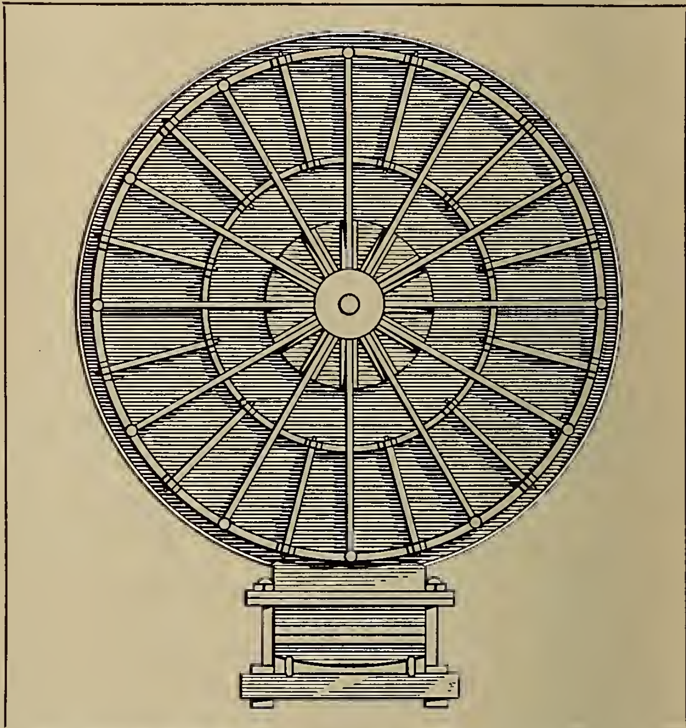
A BALANCED GASOMETER OF UNUSUAL TYPE

nearly one-half the sum which such a vessel cost as originally constructed. In the infancy of the art of lighting with coal gas, the reservoir was encumbered with a heavy appendage of chains, wheel-work and balance weights, and from the construction of the machine it was necessary to guard it from the impulse of the wind, the action of which on the gas holder would have rendered the lights which the machine supplied with gas, unsteady. Hence it was necessary to inclose the gas holder in a building, called the gasometer house, which formed one of the largest items of expenditure which the proprietor of a gas light establishment was called upon to defray. Now, however, [it is Accum speaking], the whole of these expensive appendages is dispensed with, nor is the gasometer house to contain the gas holder any longer necessary, and the machine as now constructed may be fixed in the open air.

"The gas holder, of the original construction, consists of two principal parts: first, of a cistern or reservoir of water, usually constructed of masonry, or of cast-iron plates, bolted and screwed together; and secondly, of an air-tight vessel which is closed at top and open at bottom, inverted with its open end downwards into the cistern of water. This vessel is always made of sheet-iron plates riveted together air-tight, and was suspended by a chain or chains, passing over wheels, supported by a frame work.

"If the common air be allowed to escape from the inner vessel, when its open end is under the edge of the water, in the outer cistern, it will freely descend, and water will occupy the place of the air; but if the avenue of the escape be stopped, and air be made to pass through the water, the suspended inverted vessel will rise to make room for the air. And, again, if the suspended vessel be counterpoised by a weight, so as to allow it to be a little heavier than the quantity of water which it displaces, it will descend if the entering gas be withdrawn through an outlet made in the vessel to permit the gas to escape. But if the outlet be stopped, and air again be admitted under the vessel it will rise again. The apparatus, therefore, is not only a reservoir for storing up the gas introduced into it, but serves to expel the gas which it contains, when required into the pipes and mains connected with this machine.

"According to this construction of the apparatus, the interior inverted vessel forms strictly what is termed the gas holder. It is suspended as already passing over pullies, supported by blocks and frame work, and to the chain there is affixed a counterpoise balance, of such a relative weight as to allow the gas holder a slow descent into the water, in order to propel



A REVOLVING RETORT OF INTERESTING CONSTRUCTION

the gas into the mains or vessel destined to receive it, with a very small and uniform weight. It will be obvious that when a gas holder of this construction becomes immersed in the water, it loses as much of its weight as is equal to the bulk of water which it displaces, and hence to render its descent uniform, and to preserve the gas within, of an invariable density, at any degree of immersion, a greater counterpoise is required as the gas holder rises out of the water.

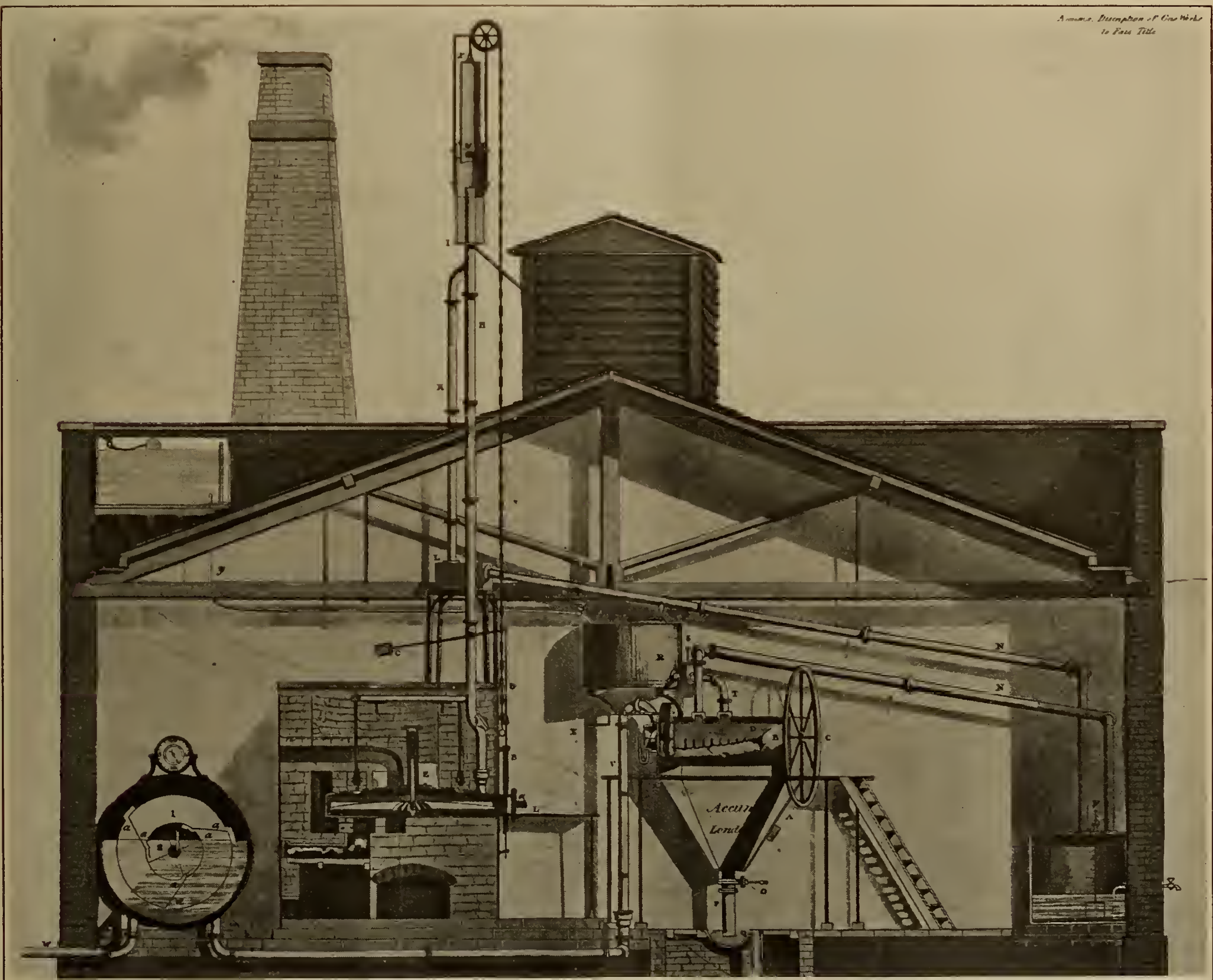
"It is obvious," continues our author, "that before the purified gas can be admitted into the gas holder, the vessel must be allowed to descend to the bottom of the exterior cistern in order to get rid of the common air which it contains. This may be effected rapidly by opening the manhole at the top of the gas holder, to cause the vessel to descend completely into the outer cistern filled with water. The manhole is then screwed up again air-tight, and the machine is ready to receive the gas. It is obvious that the operation of opening the manhole for letting out the common air requires only to be done once prior to the commencing of the working of the apparatus.

"The revolving gas holder is an ingenious contrivance invented by Mr. Clegg, for storing large quantities of gas. A

gas holder of this construction may be erected with advantage in situations where the nature of the ground will not admit of a deep cistern either above or below the ground being constructed, without an enormous expense. The base which it occupies is no larger than what would be required for a gas holder of equal capacity, built on a plan of the gas holders of which descriptions have been just given. It regulates its own specific gravity. And though more expensive in the construction, yet as it does not require a deep cistern, like the machines already described, it can be erected at the same cost. The revolving gas holder is shown. Its capacity is 15,000 cubic feet, it weighs twelve tons.

"The collapsing gas holder is a still further improvement by Mr. Clegg, on this part of the gas light apparatus, and certainly of all the contrivances which have been invented for collecting and storing up large quantities of gas, this machine must be pronounced to be by far the most simple, economical and efficient. The striking advantage of the revolving gas holder which we have just been describing, is that it enables the dimensions of the tank to be very much diminished, where the nature of the ground will not admit of a cistern of great depth being sunk, except at an extraordinary expense; but the still superior feature of the collapsing gas holder which we now come to describe is that it may be constructed of any required capacity, and adapted to a tank or cistern of such diminished depth as scarcely to deserve that name. It requires a sheet of water no more than eighteen inches in height, so that it may be constructed in or upon ground of all descriptions, not only with every possible facility but at an immense saving of expense.

"It is composed of two quadrangular side plates joined to two end plates meeting together at top in a ridge like the roof of a house. The side and end plates are united together by air-tight hinges, and the joints are covered with leather to allow the side plates to fold together, and to open in the manner of a portfolio. The bottom edges of the gas holder are immersed in a shallow cistern of water, to confine the gas. By the opening out or closing up of the sides and ends of the gas holder, its internal capacity is enlarged or diminished, and this variation of capacity is effected without a deep tank of water to immerse the whole gas holder in, as required in the ordinary construction of rising and falling gas holders. The collapsing gas holder requires therefore only a very shallow trough of water to immerse the bottom edges of the gas holder to prevent the escape of the gas introduced into it. The lower edges of the gas holder which dip in water are made to move in an horizontal plane or nearly so, when they are opened, so that they dip very little deeper in the water when shut or folded together than when opened out. For this purpose the top or ridge joints which unite the two sides of the gas holder, are slightly raised up when the sides close or approach together, or slightly depressed when the sides open out or recede from each other. To guide the whole gas holder in this movement, two perpendicular rods rise from the bottom of the shallow tank which pass through sockets in the ridge joints at the upper part of the gas holder. These sockets



AN EARLY INSTALLATION AT THE LONDON MINT; FROM LEFT TO RIGHT ARE SHOWN THE GAS METER, HORIZONTAL ROTARY RETORTS, THE PURIFYING APPARATUS AND THE TAR CISTERN

are secured by collars of leather round the shafts or rods, to prevent the escape of the gas, and they are braced by chains proceeding from their upper extremities and fastened at the ground on each side of the tank."

PART III.

Gas meters or "self-acting gages," as they were called, were early developed to a remarkable degree as were gas governors, gas mains and service pipes. The question of burners has already been referred to. We have now seen how the primitive plants were operated, and let us take a step ahead and see the condition of gas in London in the mid-Victorian period. We quote from an article of 1854:

GAS WORKS AND GAS LIGHTING IN LONDON IN 1854

"A convenient and cheap mode of obtaining artificial light is, in these latitudes, one of the greatest advantages that science can confer on the inhabitants of a large city. Those who remember the night appearance of London fifty years ago [*i.e.*, about 1800], when the dim oil lantern in the street, and the flickering candle in the shop window, served for little more than to render darkness visible, will the more readily appreciate the brilliant illumination now seen almost universally throughout the metropolis. The introduction of gas lighting has not only tended to improve the trade in the shops but has also had a most important influence in protecting property against the attempts of the robber, to whom the dark and lonely state of unlighted streets and roads has always given encouragement and shelter.

"Gas lighting is an invention of the present century, the first application of it, on any scale of magnitude, having been made by Mr. Murdoch, at Soho, near Birmingham, about 1802. A year or two afterwards Mr. Winsor, a German, exhibited it for the first time in London, and projected a company, to be called the National Light and Heat Company, for the purpose of applying the principle on a large scale. In 1807, he lighted one side of Pall Mall with gas; and having obtained subscriptions to a considerable amount, proceeded to try experiments, in which he expended the whole of the money subscribed; his supporters, however, nothing daunted, persevered in their attempt, and in 1809 applied to Parliament for an act of incorporation, to enable them more effectually and beneficially to carry on their works. They encountered much opposition, and their application was unsuccessful; but they returned to the charge and in 1810 obtained their act, which was followed on the 30th of April, 1812, by the grant of a charter of incorporation. This was the origin of 'The Gas Light and Coke Company,' more generally known as the Chartered Gas Light and Coke Company, the first established, and now the largest in London. Their first works were in Cannon Row, Westminster; but finding this site inconvenient, they removed to Peter Street, or Horseferry Road, where their principal establishment now stands. Their first trials on a large scale were very costly, as experiments of this nature must necessarily be; but in 1813 they engaged Mr. Samuel Clegg, whose name is connected with some of the greatest improvements in gas lighting, and soon after this time their arrangements rapidly improved."

THE FUNCTION OF HAEMOPORPHYRIN IN THE BLOOD

A WRITER in *Kosmos* (Stuttgart) in an article on Light as an excitor of disease mentions some curious and important facts concerning the function of one constituent of the coloring matter of the blood, *i.e.*, haemoglobin. He says:

We know today that nearly all fluorescent substances exert a sensitizing influence upon the organism and that those rays of light are most effective which excite the strongest fluorescence. It is very interesting, therefore, to learn that fluorescent substances are very widespread in the organic world and play a great part therein. Chlorophyl is a fluorescent green coloring matter which makes the tissue of plants sensitive to light and with the help of this substance the plants are able in some manner, still imperfectly understood, to produce starch and carbon dioxide and water. Careful tests have shown that chlorophyl is a true sensitizer. Infusoria placed in contact with a chlorophyl extract made from green leaves and then exposed to light quickly die, while if kept in the dark they exhibit no alteration. Red blood corpuscles when mixed with culture of infusoria quickly cause the organisms to die when exposed to rays of light.

Very recent experiments, too, have shown that in the animal organism also there exist fluorescent combinations which have been formed from haemoglobin, which we must remember is very similar to chlorophyl in many respects. These fluorescent compounds are called porphyrins and the most important of these is *Haemoporphyrin.*

Haemoporphyrin is a derivative of haemoglobin and is chiefly distinguished from the latter by its lack of iron. It is found in all normal urine, though only in traces, the amount increasing somewhat in cases of fever. Like its predecessor it has a strong sensitizing influence. When it is added to a culture of Infusoria the organisms quickly die when exposed to light, though they remain uninjured as long as they are kept in the dark. If a small amount of this substance is injected into a mouse, the animal remains quite healthy and lively as long as it is in the dark; but when it is exposed to the light (even merely to diffused daylight) the animal soon begins to scratch at the point of injection, grows restless and turns around and around, gradually becoming quieter until it becomes exhausted and finally dies.

THE REDUCTION OF DUST EXPLOSIONS AND FIRE FROM ELECTRIC LAMPS

FAULTY electrical installations and inadequate protection constitute a serious fire and dust explosion hazard in dusty industries, say specialists of the United States Department of Agriculture in Department Circular 171, A Recently Developed Dust Explosion and Fire Hazard. To prove that fire and explosions may be caused by electric lamps, the department specialists conducted a series of experiments in the laboratories of a large lamp manufacturing company.

All electric lamps in places where explosive dusts are present should, they say, be equipped with vapor-proof globes, protected by heavy guards to prevent breakage. Many of the dangerous practices, such as the use of open wiring, drop cords, unprotected lights, etc., can be eliminated by modern installation methods.

The bulletin states that explosions have occurred as a result of lowering into a bin an unprotected electric lamp attached to a cord. The lamp may swing against the side of the bin and if the globe is broken the hot filament in the lamp is exposed for an instant and the surrounding dust cloud ignites.

It is believed that any combustible dust, if allowed to collect on the lamp in sufficiently thick layers and remain long enough, will ignite. The ignition of the dust is probably due to the fact, the specialists say, that the very chaffy dusts collect on the globe where they form a blanket which prevents radiation of the heat generated in the lamp and raises the temperature of the bulb to the ignition temperature of the dust. Some of the dusts seem to melt or congeal and form on the globe a crust which does not burn readily. During the recent dust explosion prevention campaign about 20 cases were reported where explosion or fire was supposed to have been started by the ignition of dust which had settled on the lamp or by the accidental breaking of the electric lamp in a dusty atmosphere.

Under ordinary conditions, with the small lamps commonly used in industrial plants and with free circulation of air about the globe, the specialists believe it unlikely that fire will start readily. They recommend, however, that all electric lamps be equipped with vapor-proof globes. The straight-side, vapor-proof globe which prevents the accumulation of dust on the lamp may be used to maintain a low temperature. The use of drop cords and the so-called extension, or portable, lamps is probably the most common and objectionable practice and should be eliminated so far as possible.

Asbestos and What It Means to America

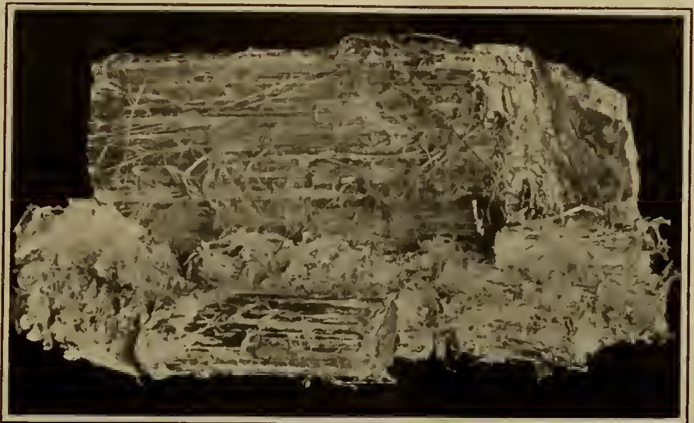
Where the Mineral Fiber Comes From, and Some of Its Applications

By Robert G. Skerrett

Asbestos was but a laboratory curiosity a comparatively few years back. Today, however, this unique mineral figures importantly in many of our daily activities, and we shall probably yet learn of more ways in which it may be made to serve us advantageously.

Asbestos is of divers kinds. Some have short filaments, others have long fibers, and there is a sort that has a strictly crystalline structure. Until recently the manufacturer insisted upon asbestos of a silky texture, and would have nothing to do with the type that was marked by longer but less flexible filaments. As might be expected, necessity has given industrial value to some of the hitherto unfavored varieties, but, even so, the preference still prevails for an asbestos which will lend itself readily to weaving or felting because of its pliant fibers. Canada supplies the world with the largest quantity of this particular kind of asbestos, known as chrysotile, and the United States utilizes by far the biggest share of this output.

According to the latest figures available, the asbestos mines of our neighbor to the north yielded, in 1919, a total of 135,861 tons of marketable asbestos, valued at $10,982,289, and of that amount we took quite 89 per cent. In other words we are in the lead as manufacturers of this material. It is true that asbestos has been found in Arizona, California, Georgia, Maryland, Oregon and Idaho. Georgia is the biggest producer, but it furnishes only fiber of the lowest grade. California ranks next, and, together with Maryland, is a source of a good quality of so-called mill fiber. Arizona at present is third in output, its asbestos being chiefly spinning fiber with a considerable proportion of the mill sort; but recent discoveries of asbestos of unusually long fiber and silky texture promise to give that State preeminence.



RAW ASBESTOS FROM THE QUEBEC MINES

Whatever may be the future development of our own resources, the system of mining the stuff will probably be much akin to that practised in uncovering the famous deposits which lie in the Province of Quebec and run, in the form of veins, through massive ledges of serpentine rock. Merely because the filaments of this asbestos may be separated from one another by the unaided fingers is no warrant for the assumption that the raw material can be recovered with anything like that ease from its prehistoric bed in the earth's crust. The mining of asbestos in Canada is, indeed, a toilsome undertaking; and for every ton of marketable asbestos a great many tons of enveloping and superposed rock must be removed. This can be appreciated when it is recalled that during 1919 a matter of 3,061,690 tons of rock was mined and taken out of the pits, from which was realized an average of only 100.8 pounds of asbestos per ton of serpentine.

Broadly stated, asbestos has heretofore been mined in open pits or quarries, and this procedure still predominates in the Province of Quebec. At the start, after exploratory borings have brought to light underlying veins of the mineral, the superposed soil must be cleared away, and this not infrequently calls for the digging by steam shovels of earth to a depth of 25 feet. With the asbestos-bearing serpentine thus exposed, then comes the actual excavation of the productive pit, and it is customary to cut and blast the rock in a series of benches, stopes, etc., which are dimensioned agreeably to the magnitude of the pit and the depth to which the work is carried. The rock so detached is then hoisted out of the pits by derricks or overhead cableways.

This serpentine is attacked by power-driven drills and the holes are next charged with dynamite containing 40 per cent of nitroglycerine. These operations demand wide experience and a pretty comprehensive knowledge of the trend of strata and sheeting planes. Otherwise much time and money can be squandered in fruitless efforts. The Thetford District of the Province, where most of the mining is done, is divided off into numerous claims, and competitive enterprises are often close neighbors. This situation has been responsible latterly for some variations in the general practice of getting out the desired asbestos.

For instance, at one mine, situated in a narrow strip between flanking claims, open-pit excavating had to be halted because the clearing had gone down to a depth where there was fear of the steep sides yielding and starting rock slides. Accordingly, the owners offset this hazard by sinking a series of shafts, and from these, some hundreds of feet below, they developed a system of drifts, galleries, glory holes, etc., similar to the features characteristic of hard-rock mining for copper, tin, gold, silver, etc. Normally, open-cut methods answer best and are the most economical, for the reason that the asbestos veins traverse the serpentine in an erratic manner, which makes subterranean mining uncertain and often unprofitable. But, as just explained, there are circumstances that have made it worth while to alter the long-established procedure in some radical particulars. Commonly, where the pit is of considerable depth and length, cableways are stretched across the excavation, and by these the rock is lifted to the surface and then conveyed to convenient dumping points. In the larger of the pits these steel lines span an interval of 400 feet and more. About three years ago some of the Thetford mines began to abandon the hoisting of the quarried material by means of these agents and adopted, instead, what is technically known as the "glory-hole system," which entailed the handling of the stuff by shaft. So well has this innovation worked that it is authoritatively declared that the method is likely to become the prevailing one hereafter.

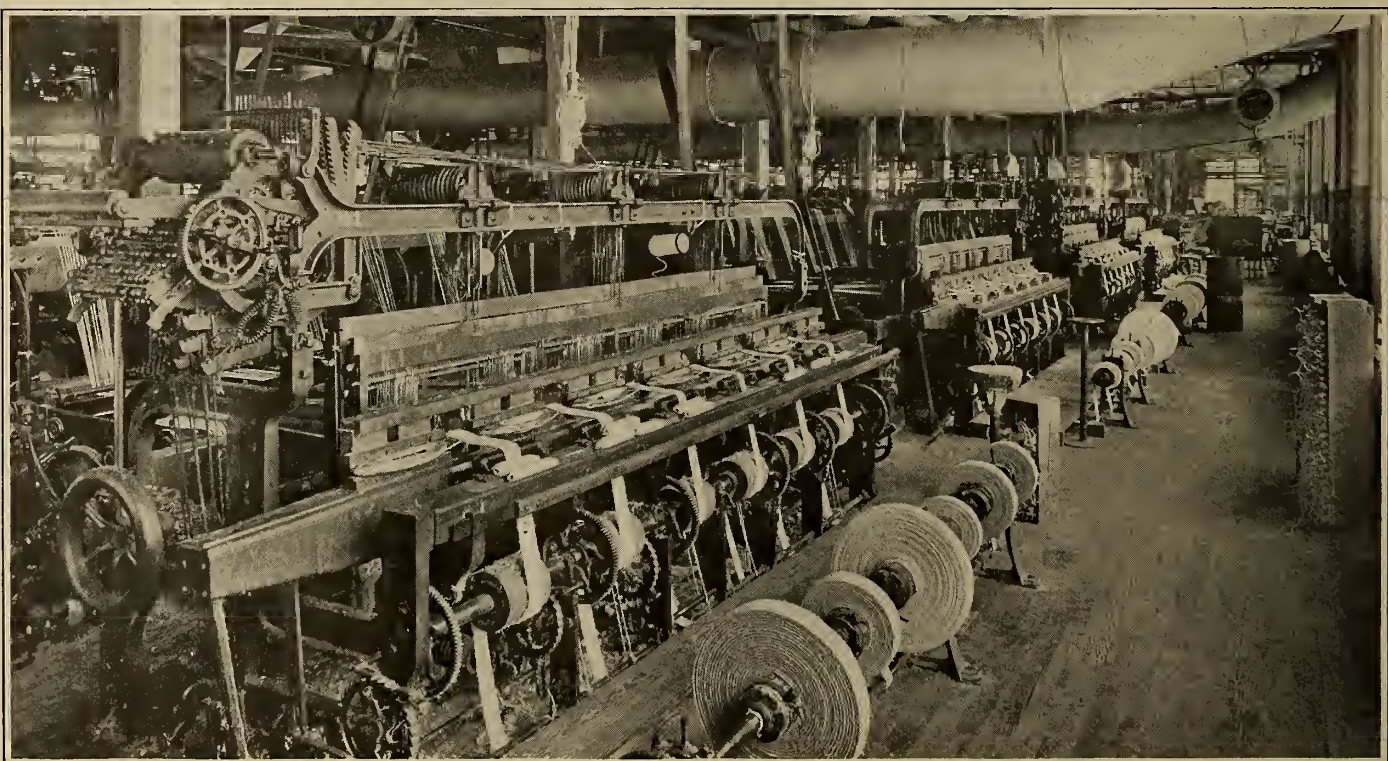
In a general way, the new practice is a wedding of open-cut and underground mining, or, to be more specific, the quarrying is done in the open, while the hauling of the blasted rock is below ground. The ore reaches the surface thence by suitable lifts installed in a main shaft. From the main shaft, which is sunk outside but near the glory hole, as the familiar quarry is called, are driven levels reaching far into the asbestos deposit, and from these levels radiate cross-cuts. The latter constitute points of departure for a series of smaller vertical shafts which rise until they break through the floor of the glory hole. Their uppermost terminals are funnel-shaped,

WHERE ASBESTOS IS TRANSFORMED FROM A SHORT MINERAL FIBER INTO A TEXTILE; MULE SPINNERS ON THE LEFT AND AT THE RIGHT, THE YARN ON BOBBINS READY FOR SPINNING

and into them the asbestos-bearing rock is dumped as it is mined. These "mill holes" are the mouths by which the mineral descends into chutes which, in turn, discharge into little mine cars traversing the cross-cuts below. Trains are then made up of these laden cars, which travel via the levels to the main shaft, where suitable connections are made with the hoisting equipment. Some of these shafts reach down to a depth of more than 500 feet.

After the ore has come out of the mine it is then subjected to dressing or "cobbing," *i.e.*, separating the asbestos fiber from the rock. Mechanical means are employed for this service save in the treatment of the higher grades of the stuff, such as Nos. I and II, where hand dressing is relied upon because it is possible only in that way to avoid the inevitable tearing of the fiber. The workers that do the cobbing are experts, and they skilfully break the asbestos clear from the serpentine by hammer blows. In the first dressing they use one-hand sledges weighing about six pounds, and the released fiber is screened from the shattered rock by 3/16th-inch mesh. The remaining ore is carried to a second cobbing shed, where most of the contained asbestos is freed by operatives equipped with lighter hammers. The resulting material is then screened twice to get rid of any adhering rocky particles and to separate the fibers into grades I and II. This asbestos is known to the trade as "crude." The refuse from the cobbing tables and the waste from the screens are next handled mechanically in a mill.

Mechanical cobbing is done by an apparatus commonly called the "cyclone." Briefly, the machine consists fundamentally of a strong metal casing that houses two oppositely revolving propellers, and these throw the pieces of ore at great speed against the enveloping walls or back and forth



THE MACHINES THAT MAKE ASBESTOS BRAKE-LINING FOR AUTOMOBILES, THIS FABRIC BEING COMPOSED OF ASBESTOS YARN INTERWOVEN WITH WIRE TO GIVE THE NEEDED TENSILE STRENGTH

upon the blades of the opposing rotors. In this way the serpentine and the fiber are broken apart. By an induced draft the comminuted rock and the fluffy asbestos are extracted from the "cyclone" and are next carried over a number of agitated screens, which segregate the fiber from the granulated or pulverized substance. A second suction system now gathers up the asbestos filaments and discharges them into settling chambers. In passing, it should be said that the original blocks of serpentine are reduced in size by one or more crushers, and that the average piece so prepared for the "cyclone" does not measure more than an inch and a half. Furthermore, the broken ore is put through rotary dryers to get rid of the moisture which would be apt to interfere with the releasing of the asbestos by the mechanical cobbers.

Inasmuch as the filaments are of various lengths when they reach the settling chambers, it is essential that they be assorted subsequently into the grades known to the trade. This is done by sifting the material through screens of different-sized mesh. With this work finished, the asbestos is packed in bags ready for the manufacture of all sorts of asbestos commodities. Asbestos not classed as crude, agreeably to the requirements already mentioned, is known as "fiber" or "mill" asbestos, and while this is not suited to spinning and weaving, as is the silky thread-like crude, still it is capable of being worked into a large number of useful forms.

In the years gone, when we first put asbestos to use, it was employed principally in sheets as a barrier against flame and to a lesser extent as a heat-insulating material. As time went on the durability of the stuff and its potential value in other directions became evident, and out of this realization has evolved an industry of considerable magnitude. Indeed, it is not overstating the case to say that we would be pretty hard put to it if we could not command the asbestos products now on the market. For architectural purposes we have today asbestos shingles, felt, mill board, flooring and paper; asbestos is worked into automotive equipment in the shape of tape, brake lining, packing, etc.; it is fabricated into insulation for boilers, piping, etc., and it is a prime constituent in refractory cements, various fireproofing compounds, and packing for divers mechanical uses where heat and acids have to be dealt with. Again, asbestos possesses a cloaking or protective quality of merit in confining cold or in shielding from the effects of low temperatures; and the stuff is utilized variously in electrical installations as an insulator and as a screening or sheltering blanket. In fact, asbestos is decidedly unique in combining the dual qualities of an insulator of both heat and electricity. A good grade of asbestos tape will stand a rise in temperature of 527 degrees Fahrenheit before a breakdown occurs and is proof against electrical puncture up to 250 volts. On the other hand, some asbestos goods will stand a temperature of 4000 degrees Fahrenheit.

Finally, to bring asbestos still closer to us, the manufacturers are now turning out wearing apparel in which this mineral is helpfully incorporated. That is to say, aprons, coats, gloves, overalls, shoes, and whole suits, with or without helmets, are now available. Most of us are familiar with the asbestos household articles, such as baking sheets, stove mats, table covers and pads, flatiron holders and the like. And then at the show, for our further security, there are theater curtains and booths for motion-picture machines of asbestos. All of these applications of asbestos are suggestive hints of possibly wider fields in which it may serve us in the near future.

HOW THE MINERAL FIBER IS FORMED INTO BOARDS AND SHEETS OF FIRE-RESISTING AND INSULATING VALUE

Left: In the pulping mill, where the asbestos fiber and the binder are thoroughly mixed by mechanical beaters, preparatory to being formed into sheets in the manufacture of insulating paper, mill board, etc. *Right*: The band-saws employed in trimming the edges of asbestos fire-felt blocks, lagging, and similar material

As may be appreciated, asbestos fiber of the best "crude" is not as strong as many filaments of vegetable origin, such as cotton and flax, but, even so, manufacturers have succeeded in producing asbestos thread of sufficient tensile strength to answer admirably for numerous purposes. Threads of this sort are now made that weigh but an ounce per hundred yards, and these are woven into various fabrics. To prepare the fibers for spinning they are first carded and then condensed in a manner akin to the procedure in vogue in the ordinary textile plant. But, as might be expected, because of the dis-

tinctive characteristics of asbestos, it has taken time and much experimenting to evolve machinery suited to the work.

The fiber is first formed into "slivers." These are coiled in cans and carried to the spinning department, where they are twisted into threads. Once brought to this state, the asbestos is then fit for weaving, and is next fed to the different apparatus which fabricate it into yarn, tape, or cloth, agreeably to the uses to which it is to be put. As will be readily understood, the yarns are wound upon bobbins and spools to facilitate the operations at the several machines. For certain commodities, where strength is an essential factor, wire and asbestos are woven together; and it is in this manner that brake-shoe linings, for instance, are manufactured.

The production of mill board, in which short-fiber asbestos is employed, is fundamentally a duplication of the course pursued in turning out pasteboard — in short, is analogous to paper-mill practice. The asbestos fiber is dumped into tanks, where it is subjected to the action of a rotary beater, and the stuff is pulped and mixed with the other ingredients that constitute the binding medium. The latter is commonly a type of hydraulic cement. When the pulp has reached a proper consistency it is discharged into a vat, where it is continually agitated until picked up by a screen which envelopes a rotating cylinder. From the cylinder the mushy stuff is transported by an endless belt to a set of metal rolls and is there pressed for the purpose of getting rid of a good deal of the contained water. Gradually, upon the upper of the two cylinders, are built up layers of the plastic material, and, when the accumulation is of sufficient thickness, it is removed from the cylinder by a single lengthwise cut.

When sheets of this nature leave the rolls they are placed in hydraulic presses between flat steel plates, where still more of the residual moisture is expelled. After a proper seasoning period this mill board or asbestos "lumber" is ready for distribution to the trade. The stuff can be sawed, cut, drilled and nailed easily, and is widely employed for paneling, for wainscoting, for ceilings and partitions.

Asbestos paper is manufactured from fiber ranging from that too short to measure up to filaments having a maximum length of half an inch. This stuff is known to the trade as "paper stock," and in producing the paper between 5 and 10 per cent of the composition is a binder which varies according to the use to which the finished article is to be put. The binder, which is needful to give the asbestos paper the desired tensile strength, may be starch, flour, cold-water paste, silicate of soda, etc. Lime answers well as both a cementing and a hardening ingredient. Generally speaking, asbestos paper is made along much the same lines as those pursued in the cases of heavy chip and box boards, and its preparatory treatment does not differ mechanically from that of asbestos mill board save, of course, that the sheets, formed on the pressure rolls, are much thinner. Asbestos paper is sometimes only one-hundredth of an inch thick and will then weigh about 3½ pounds for each 100 square feet.

Asbestos paper is very largely utilized in the forming of blocks and sheets for insulating ovens, ranges, oil and gas stoves, dry kilns, portable field kitchens, etc. It is also put as a lining in safes and other metal office equipment designed for the better storage of papers, documents, and records that would quickly perish if exposed to high heat or flame. Asbestos paper is now worked into the armatures of electrical apparatus as a medium for insulating the various parts from one another. And, latterly, a form of asbestos paper has been made that is being fashioned into mail bags for the aerial postal service. Manifestly, this is a precautionary measure intended to protect the mail matter from fire should the planes come to grief through leaky fuel tanks or a conflagration following a disastrous landing.

It is unquestionably true that asbestos shingles, asbestos roofing, and asbestos weather board minimize fire hazards; and extensive experience has demonstrated that buildings have gone up in smoke and flame while those exposed to the same peril but shielded by these asbestos materials have escaped. The wooden shingle is all too frequently tinder to the wind-swept spark, while the asbestos shingle or roofing is immune to this menace. Not only that, but the asbestos shingle has a long life; and both the shingle and the slab or corrugated roofing are unaffected by the weather and by any acids that may be carried in the atmosphere.

Asbestos cement is a commodity that is steadily growing in demand, and it is widely used as an insulation against heat. Asbestic, which is composed of the more minute particles of asbestos, is applied to walls and ceilings as a plaster and, of course, minimizes the effects of flame and cold. On account of the progress in the art, asbestos, whether of the classes termed "crude" or "fiber," can be worked up in some manner to give it marketable value and to fill a want. This has reduced to a minimum the waste of the mineral when once the stuff is mined. Manifestly, it behooves us to open up the deposits of asbestos within our own boundaries wherever the quality warrants exploiting; and there is reason for the belief that some of these veins give promise of yielding large quantities of superior sorts. From a curiosity asbestos has become a necessary commonplace, and American inventiveness and mechanical cunning have achieved this in but a few years.

Ultra X-Rays and Cosmogony*

The New Theory of Radioactivity and Its Bearing on the History of the Stars

By Jean Perrin

LET us imagine for a moment that we, ourselves, are making such a voyage that we are at least able to observe in every detail that which is occurring upon the Moon, for example, or upon Venus or Jupiter. We should certainly expect to find novel sights spread before our eyes, but among the most important changes, implying the most profound differences, even in phenomena, which at first glance appear to be entirely independent, perhaps we should have to place those changes which we should find in the phenomena of radioactivity.

There is no reason, in fact, why the Ultra X-rays issuing from the planet should be exactly similar to those upon the earth. It seems quite possible that not only their average intensity but their relative proportion in function of frequency would have changed. In a word we may assume that each planet has its own particular "spectrum" of Ultra X-rays in accordance with its size, with the thickness of its solid crust in case it possesses one, with the activity of its internal fires and with the degree of evolution of the materials of which it is composed. Thus the average lives of the radioactive elements would not only differ from their lives upon the Earth, but they would not be in the same ratio; even the order of the various kinds of radioactivity would change, perhaps—a given element which was more durable upon the Earth becoming less so elsewhere.

Possible Evolution of Life.— And when we recall that our radioactive bodies exert a profound effect upon living cells and especially upon the phenomena of cellular division, the thought occurs to us that possibly our Ultra X-rays may have an influence upon the evolution of life.

*Translated for the *Scientific American Monthly* from *La Revue du Mond* (Paris), for Feb. 10, 1920.

Perhaps upon some other earth similar to our own, but emitting different kinds of Ultra X-rays, the same sort of living creatures are not able to exist in the form we know and must either adapt themselves through modification to their environment or disappear. Thus each of these planets which were indeed deified by the ancients, may have its own secret personality—a nature perilous to the visitor from afar.

In the vicinity of the sun or of the stars the magnitude and the order of the various kinds of radioactivity would doubtless be still more profoundly altered. There, for example, radium could be only a fugitive element imperceptible in our spectroscope. Likewise we may conceive that such an element —unstable at the surface of the stars—might be found in considerable proportions in cosmic conditions so different, wherein, indeed, the characteristic spectral rays of nebulæ reveal to us the existence of those atoms to which the name of nebulium has been given, whose weight places them between those of hydrogen and those of helium (Buisson and Fabry). One might have expected by reason of the low density which results to find these atoms of nebulium, like hydrogen and helium, in the upper strata of the solar atmosphere, and if they are not found there perhaps the reason is that they have been disintegrated (into hydrogen?) by the Ultra X-rays which traverse this atmosphere (or again, perhaps it is because they have been captured to form constituents of the atoms not broken up by these rays).

THE REGENERATION OF RADIUMS AND THE FORMATION OF HEAVY ATOMS

In indicating the conditions under which one might hope that radium may be regenerated at the expense of radon and of helium I have left the reader to guess the regions where I supposed this regeneration to be possible. Just as it is necessary to heat ozone to a high temperature in order to hasten its transformation into oxygen, in the same way the action of a temperature truly enormous will here be necessary to provide in sufficient quantity the regenerating radiations, less penetrating than the Ultra X-rays, but certainly still of very high velocity frequence.

But these regions of the universe in which the temperature is actually enormous are quite well known to us. Without going any farther to begin with under our very feet, within the deeper strata of this terrestrial globe, it is probable that light atoms of the hydrogen type are combining with each other to form heavy atoms of the radium type, at the same time liberating in the form of Ultra X-rays a formidable amount of energy which is utilized in supporting the central fires. Some of these Ultra X-rays even arrive at the cold strata of the surface, and it is these rays which produce within the few heavy atoms these strata contain, the phenomena of radioactivity which strike us as being so remarkable. It is entirely a secondary phenomenon: the principal transformation is effected in the first stage: *i.e.*, the production of heavy atoms.

ORIGIN OF SOLAR HEAT

Thus the light atoms, upon coming to approach each other sufficiently close (under the enormous pressure exerted by the deeper strata) and being subjected to an intense heat will produce heavy atoms, while liberating during the process an amount of energy immensely superior to that which sets the reaction going. This phenomenon, which is at bottom, that familiar in all forms of combustion (since it is necessary to "ignite" carbon before it will burn) seems to me to furnish an adequate explanation of the source of the sun's fires.

We are well aware of what a prodigious radiation the sun throws off into space without any apparent exhaustion and without any known form of compensation—an amount which would suffice to melt every second a cube of ice having an edge 1,000 km. in length. It appears that the origin of this enormous expenditure of energy is not to be found in chemical reactions; the most violent ones that we know of would scarcely suffice to maintain the fire of the Sun for more than a few thousand years—it would be a period of only 2,000 years in the case of a Sun made of carbon and oxygen. Lord Kelvin has pointed out that the condensation of the primitive nebula (the fall toward the center of the constituent particles) under the sole action of gravitation would constitute a far more important source of energy. The energy of gravitation thus consumed in the formation of the Sun would correspond (so enormous is it!) to about 30 million years of actual radiation. And it is necessary, says Kelvin, that geologists should content themselves with this period of time.

But they do not so content themselves. For the history which tells us of the strata slowly deposited at the bottom of the seas and containing fossil detritus very similar to those organisms which still exist can scarcely permit us to believe that the earth and the sun have undergone any very great amount of change if indeed they have changed at all, for a billion years. Moreover, we can see no sign of any approaching change close at hand. The theory is insufficient, therefore.

EVOLUTION OF THE STARS

We can remove this difficulty by our present theory. Let us imagine that the infinitely minute particles of dust or the isolated molecules which form the primitive nebula more or less analogous to that of Orion, are composed of very light atoms such as those of hydrogen, of nebulium or of helium.

In hurling themselves against each other, at the velocity which they have perhaps already had in coming from afar or that they have acquired in falling toward the center of the nebula, these particles liberate heat; and the mean temperature rises by many degrees (12,000 deg. in the nebula of Orion, according to Fabry and Buisson). Thus, on the one hand, since the nebula is contracting the conjunctions between light atoms capable of uniting to form heavy atoms must become more and more numerous and, furthermore, since the temperature is rising the intensity of the radiations which are capable of causing these unions must continually increase. For this double reason the formation of heavy atoms will become very considerable, growing more and more important and accompanied by Ultra X-rays which, for the most part, do not issue from the star whose temperature becomes enormous: *The star is ignited.*

This ignition takes place through a mechanical process which is definitely comparable to that which starts the combustion which takes place in a brasier when the latter is raised to a high enough temperature. It is this which served to occasion the liberation of heat considered by Lord Kelvin and due to the condensation of the nebula. And we can easily understand from our study of the energies exhibited in radioactive transformations, that the mass of the sun can easily maintain its radiation at the present rate for several billion years and, perhaps, for many, many billions. To sum the matter up we thus return to the ancient idea of a combustion, but in this case our concern is not with a combustion in which the atoms barely penetrate each other as in the formation of carbon dioxide, but with a profound penetration which mingles with each other in a far more intimate fashion, the atomic nuclei. This is the formation of the heavy atoms (of the radium type) at the expense of the light atoms (of the hydrogen type), or better still it is the disappearance of electrical potential energy and not of the energy of gravitation which causes the prodigious lavishing expenditure of stella radiations. This enables us to understand how the error committed with respect to the sign of the variation of energy which accompanies the radioactive transformation rendered inexplicable a problem which is really quite simple.

During this spontaneous combustion of the star the radiation will pass through a maximum and will then decrease; the superficial layers will cool off and, finally, a solid crust will form at once protecting the star almost completely against continued cooling. Having become similar to our own earth, this star, where the atomic condensation slowly comes to an end, will travel through space, during a period of time which will possibly be enormously long compared to that during

which it was refulgent. Sooner or later, however, it will clash against another star—one still shining perhaps, but more probably one already extinguished. If the comparative velocity of the two stars, while they were still at a great distance from each other, were of the magnitude of 50 km. per second, as is the case ordinarily in the Milky Way, it would be much greater at the moment of the shock—becoming 500 km. per second by reason of the acceleration produced by gravitation.

We have just seen how impossible it is to believe that the force of gravity alone can suffice to really rejuvenate these stars which crash against each other in the heavens. In order to secure this rejuvenation so that the cycle may be completed, as Arrhenius has conceived and set forth in his beautiful treatise upon cosmogony, it is necessary, above all, that there should be some mechanism in operation whereby there may be recuperated the enormous flux of energy which streams forth from the stars, and nothing comparable to which returns to them. (What would happen, for example, if the velocities of interstellar shocks were of the order of 20,000 km.-sec., which does not occur in the portion of the universe which we perceive? In order for this to happen, it would be necessary, in my opinion, for the cosmic dust driven afar by radiation, to have definitely transformed into kinetic energy the entire radiation of the stars.)

A space sufficiently great to accommodate this sort of recuperation would function as a medium absorbing light; this amounts to saying that beyond a certain distance the stars would no longer be visible. The remote *Galaxies* which we perceive, at a distance perhaps of 100,000 light-years, far beyond that Milky Way which surrounds us, suffice to prove that if such a recuperation occurs, it demands, at all events, a space enormously more extensive than the space which our telescopes have been able to penetrate.

Furthermore, it is in no way certain that the universe is to be regarded as a static state of equilibrium in which matter and light pass through a cycle whose majestic ensemble can be grasped by our finite minds. It can not be denied that within the most far-extensive limits wherein we can either know or divine the nature of this universe, we observe that it is a state of evolution, and is not remaining stationary. And if we confine ourselves to the sole fragment of evolution which we are able to grasp—of the period before and after which we know nothing—we must limit ourselves to the declaration that during a period of something like a trillion years matter must have passed from a nebulous state, in which it consisted of atoms of light weight, into a state of heavier and heavier atoms, grouped in larger and larger stars. Meanwhile a prodigious torrent of light has disappeared into infinite space.

The Perfume of the Orange

The Neroli Oil of the Riviera and Its Place in Commerce

The flowers of the bitter orange and of the sweet orange can be distilled in the same manner as are roses. The former yields an extremely choice perfume known as orange flower oil or neroli oil, the perfume obtained from the sweet orange is called neroli-Portugal oil and is much inferior. All along the charmingly picturesque French Riviera the bitter orange is especially cultivated for the purpose of distilling perfume from its blossoms and leaves.

The oil is at first nearly colorless, or with but a faint yellow tone, but when kept it becomes reddish-yellow eventually. It is very limpid, but when seen in a clear glass has a bluish opalescent tone. The taste is somewhat bitter and the odor, while strong, is very delightful. Its specific gravity ranges from 0.85 to 0.90. While but slightly soluble in water it imparts a pleasant fragrance to the latter; orange flower water is colored red by sulfuric acid.

When 1 to 2 parts of 90 per cent alcohol are added to the oil, a clear solution is obtained; when more alcohol is added this solution becomes turbid and after being allowed to stand stearoptene separates from it in flakes. Unless kept with great care the oil becomes darker in tone and even unpleasant in odor. However, when thus injured it can be rectified with water. Since neroli is very expensive, it is, like rose-oil, much subject to adulteration; in fact, one cynical authority asserts that there is absolutely no genuine oil on the market and that what is known as pure neroli oil consists, on an average, of one-eighth part oil of bergamot and three-eighths of petit-grain, with only 50 per cent of the real neroli. A simple test for pure orange flower oil is to pour 1 or 2 drops upon sugar and then stir the sugar in water. If the oil is adulterated the water has a bitter taste. A test of more precision is to mix three drops of the oil with 40 to 50 drops of alcohol in a test tube and when entirely dissolved to add about one-third the volume of the whole of concentrated sulfuric acid. The solution of oil and alcohol is then mixed with the acid by a careful shaking of the test tube. If the oil is pure the resultant mixture will be turbid and either reddish or dark brown (the latter if the oil is old); almost all other oils used for adulterants give paler colored mixtures.

The odor of orange flowers is due to the presence of two volatile oils, one of these has a much more delicious odor than the other and it is this which is soluble in water, hence the somewhat faint but very agreeable fragrance of orange flower water. The other volatile oil is also fragrant and is sparingly soluble in water, but its perfume is much less delightful. The neroli oil of commerce consists chiefly of this second oil, and this is why the best orange flower water cannot be prepared by saturating water with neroli oil, but is obtained as a by-product in distilling the oil.

Neroli is in great demand in the manufacture of the choicer kinds of perfume, being a necessary constituent, indeed, of eau de cologne. It must be carefully kept in a dark place and protected from air and is not "ripe" enough to use until it has been stored for at least a year; but if it becomes too old it tends to become rancid, though this may be prevented by mixing it with an equal volume of fine spirits of alcohol.

The process of maceration or infusion is employed for flowers with but little volatile oil or whose odoriferous substance would suffer decomposition or adulteration by distillation. The process is founded on the affinity of odoriferous substances for fatty bodies which, when impregnated with them, are called *pomades*. These are afterward made to yield the aroma to strong alcohol, so that finally there is obtained a solution of the volatile oil in alcohol from which the pure oil is obtained by distilling off the alcohol. The fat used, olive oil, lard, etc., should be entirely neutral, *i. e.*, free from every trace of acid. The fats are purified by treating them in the heat with weak soda-lye and then washing carefully with water until the last traces of the lye are removed and the fat shows no alkaline or acid reaction.

With the use of olive oil the so-called "*Huiles antiques*" are obtained, which are merely solutions of volatile oils in the fixed oil. By the use of lard, etc., the genuine *pomades* are obtained, which are directly used as expensive articles of perfumery, but in the factories serve as a starting point for the preparation of volatile oils.

The old process of maceration, which is still in use in some parts of France, is as follows: A certain quantity of fat is

placed in an enamelled iron or porcelain pan provided with a water or steam bath. When the fat is melted, the freshly gathered flowers from which the aroma is to be extracted are thrown in and left to digest for from 12 to 24 hours, the fat being kept fluid and stirred frequently. When the flowers are completely exhausted, the fat is strained from them into fresh pots, in which it is again macerated with fresh flowers as before. This operation is repeated 10 to 15 times until the pomade has acquired the desired strength.

Experience, however, has shown that volatile oils prepared for this process possess a finer odor the shorter the time the flower remains in contact with the fat. Piver has devised an apparatus which reduces the time of maceration to the shortest period possible.

Maceration is employed for the flowers of the orange (*vitrus aurantum*) of the mock orange (*Philadelphia coronarius*), of the acacia (*acacia Farnesiana*), of the violets (*viola odorata*), of the mignonette (*reseda odorata*), etc.

The process of *absorption*, or "*enfleurage*," is it is called by the French, is chiefly made use of for procuring the odoriferous principle of very delicate flowers, the delicious odor of which would be greatly modified, if not entirely spoiled, by the application of heat. The older apparatus employed for the purpose consists of a number of shallow wooden frames of about 15 by 18 in., inclosing at half their depth a sheet of glass. The edges of the frame rise about an inch above each surface of the glass, and, being flat, the frames stand securely upon one another, forming often considerable stacks. These frames are called "*chassis*," those just described being termed "*chassis aux vitres*," or "*chassis aux pomades*," to distinguish them from a different form, which is used where oil has to be submitted to the process of absorption. The process in the case of pomade is as follows: Each sheet of glass is uniformly coated with a thin layer of purified grease, care being taken that the grease does not come in contact with the woodwork of the frames. The flowers are then thinly sprinkled, or rather laid, one by one, upon the surface of the fat, where they are allowed to remain one or two days, when they are removed and replaced by fresh ones. The operation is thus continued for 25 or 30 days, until the fat is saturated with aroma. The frames charged with fat and flowers are stacked one upon the other, forming, in fact, a number of little rectangular chambers.

PICKING ORANGE BLOSSOMS FOR THE PERFUMERY TRADE

For *perfuming oils* a metal sieve is substituted for the glass plate. Upon the sieve a piece of thick cotton cloth saturated with oil is laid, and upon this the flowers are scattered. The operation is repeated until the oil is sufficiently impregnated with aroma, when the cloth is subjected to pressure and the expressed oil filtered.

This process is very tedious, requiring much labor and a long time for the impregnation of the fat or oil, but, notwithstanding its faults, it is still pursued to a great extent, some French firms using 3000 such frames during the season.

The picturesque little town of Grasse, in the south of France, is the center of the perfume industry. For all perfumes except those of the rose and the orange the same process is employed; but tese two stand out as arts in themselves.

REINFORCED CONCRETE IN THE LIGHT OF GEOLOGY

A German officer, Major W. Kranz, connected with the Geological Institute at Würtemberg, calls attention in *Die Umschau* (Frankfurt) for April 23, 1921, to the inadequate attention which has hitherto been paid in tests of concrete to the character of the crushed stone employed in its production. He states that in the early part of 1917 he first pointed out that geologists should be employed to test the stone used in making concrete with respect to its hardness, its granular nature and any impurities such as loam or clay which it might contain.

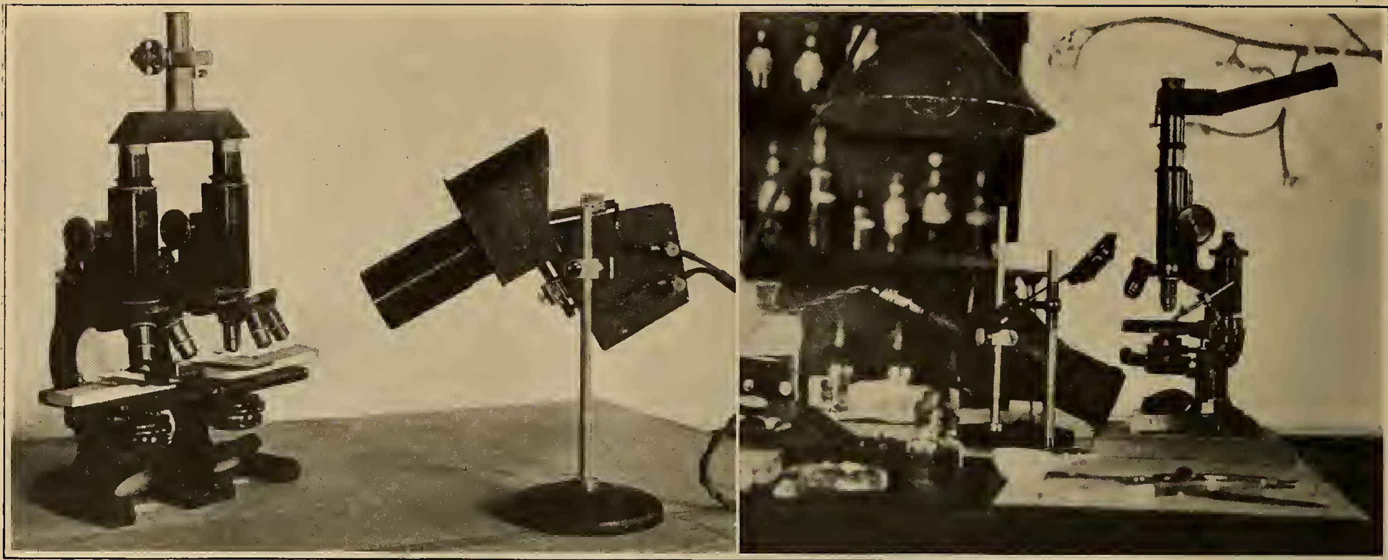
Special experiments were made to determine what kinds of stone and what mixtures were particularly well fitted for making reinforced concrete of a bomb proof character. Since reinforced concrete of great strength is not only useful for military purposes but for such peaceful enterprises as the building of canals, sluices, bridges, tunnels, etc., it is worth while quoting Major Kranz's conclusions, which are as follows:

Smooth pebble-stone or pebbles were even after a lapse of 28 days usually faultily incorporated in the concrete. Unfavorable petrographic qualities in the rock markedly decreased the firmness of the concrete made from it. Unduly large amounts of loam and marl in the sand and gravel employed betray themselves in broken surfaces of the concrete through deposits of finely divided loam and by lumps. A small amount of marl or loam, on the other hand, did not injure the concrete; in general loam and clay had a worse effect upon the resistance to pressure possessed by the concrete than equal amounts of marl. Flints or cheil in gravel sand become well incorporated with the concrete and do not injure its quality. Stream deposits rich in chalk are disadvantageous because of the softness of the stone, unless mixed with a certain amount of hard stone, in which case the concrete is improved.

As broken and chipped stone lime-stone of different geologic origin exhibited a very various degree of resistance to pressure in the form of concrete. Variegated or "new red" sandstone proved on the whole to be rather ill-fitted for the purpose of making concrete.

Fresh hard-stone, in the form of broken stone and chipped or flaked stone was found excellent—it could also be used at times in the form of crushed sand; sometimes, however, when thus finely crushed it was found to contain an undesirable amount of dust, even after it had been well washed. Weathered slag-stone from quartz-porphyry proved to have too low a degree of resistance to be useful in making concrete. Much weathered coal slack of porphyry granite cannot be used in making concrete when great strength is required in the latter.

No general rule can be formulated with regard to this matter because of the great variety, which exists among the materials found in nature. But on this very account, whenever reinforced concrete is to be used in important constructive work, it should be subjected to careful tests both previous to and during its employment by competent technically-trained geologists. It is necessary therefore that such a geologist should have personal intercourse with the officials, foremen, and workmen engaged in the various operations.



SOME OF THE APPARATUS USED IN THE TESTING OF FURS AND FABRICS, TO DETERMINE DURABILITY AND GENUINENESS
Left: Two microscopes fitted with the comparison ocular, with blocks from the attritiometer in place. *Right*: A microscope utilizing the highest powers, for the examination of individual hairs

Durability of Furs and Fabrics

Recent Methods of Determining the Resistance to Wear of Fur and Fabric Hairs

By Leon Augustus Hausman, Ph.D., Cornell University

WHAT is it which gives to furs their different wearing qualities? Some furs are notably poor in such qualities, while others bear a reputation for durability. In fabrics, too, there exist well-known differences in resistance to ordinary wear. Sometimes, no doubt, these differences bear a direct relation to the processes through which the animal hairs which make up the fur or fabric have passed while being prepared for the market. But, as a rule, the durability characteristic of furs and fabrics is determined by the structure of the individual hairs, and particularly, the writer believes, by the cortex element in each hair-shaft.

Fig. 1 shows a typical mammal hair, much magnified. It will be seen that the hair is composed of: the *cuticle;* an outer layer of flat, scaly cells, overlapping each other like the scales of a fish; the *medulla*, a central pith-like structure built up of piles of cells and arranged in various ways in different species of animals; and the *cortex*, or rigid and solid portion of the hair-shaft, composed of elongate, fusiform, horny, glassy cells, which have become fused together into an almost homogeneous mass. It is this latter element which gives strength to the hair. The greater, in proportion to the medulla, the cortex, the greater the resistance of the hair to wear.

The medulla, on the other hand, is an element of weakness in the make-up of the hair-shaft, for this structure is composed of empty, or nearly empty, cells, often with loose strands of elastic substance ramifying between them. Hence, if this element is great in proportion to the cortex, the hair becomes, in effect, a nearly hollow cylinder, which is easily broken. Microscopic examination of worn hairs shows that fur hair possessing a large medulla does, in fact, break up in just this way. (Figs. 2, 3.)

An examination under the microscope of fur-hairs from various species of animals will often yield sufficient data, concerning the size and structure of the medulla and cortex ele-

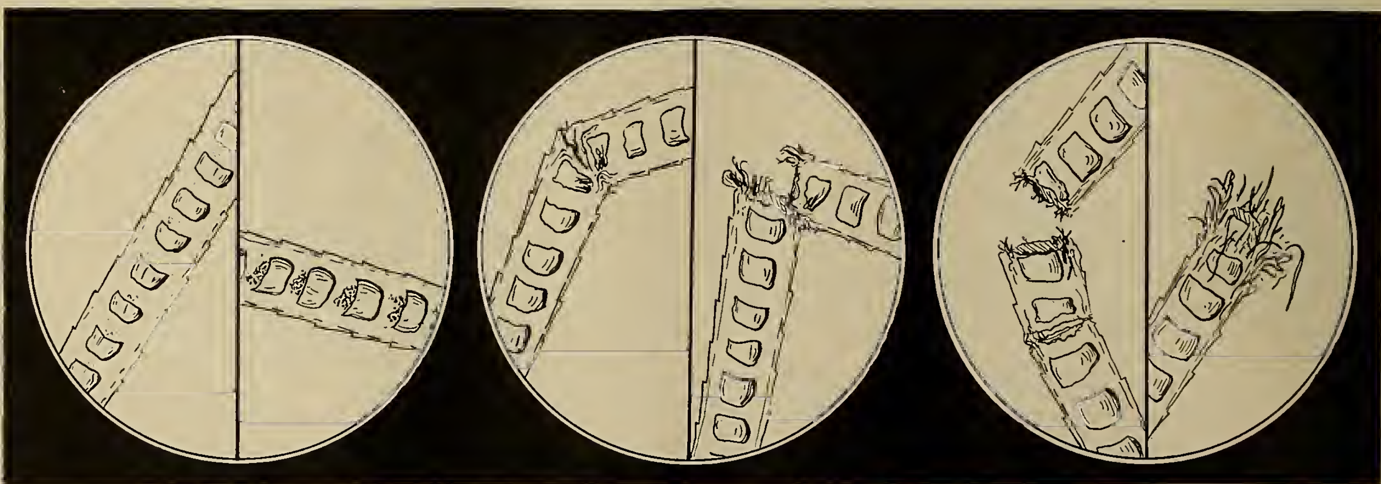


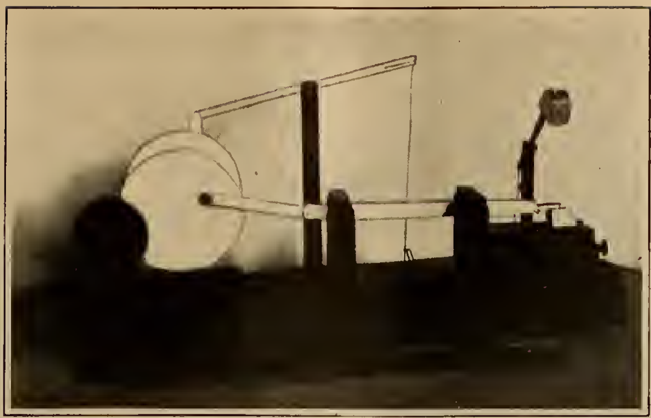
Fig. 1. Fur hairs of the gray Flemish rabbit (left) and the New Zealand red rabbit (right), seen in the comparison ocular

Fig. 2. Earlier stages in the break up and subsequent progressive wear of the fur-hair of an ordinary rabbit

Fig. 3. Final steps in this distintegration, which is characteristic of fur hairs from the majority of fur-bearing animals

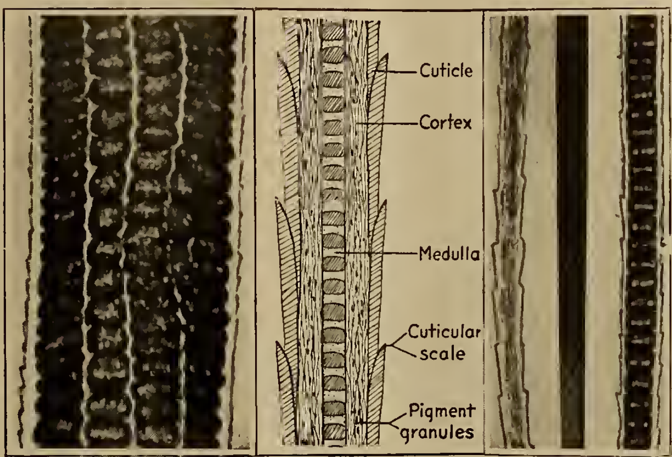
TYPICAL RESULTS OBTAINED BY DR. HAUSMAN WITH THE INSTRUMENTS AND METHODS DESCRIBED IN THIS ARTICLE

ment to make possible an evaluation of the probable wearing qualities of the furs. In Fig. 6 are shown photomicrographs of two fur hairs of vastly different wearing qualities. The fur hair of the American Otter represents one of the most durable of all the furs, being taken as 100 in the general estimate of relative fur-durability. In practically all of the fur hairs of this species the medulla is absent, the dark streaks seen in the hair being the masses of the pigment granules, which give the color to the hair. This means that the entire hair-shaft is a solid, almost homogeneous horny, elastic rod, well adapted to withstand attrition. At the opposite extreme, in durability, stands such a fur as that from the mole. A single fur hair from the common European Mole is shown in Fig. 4, at the right. This fur is usually rated between 5 and 7, on the basis of 100, in durability. A glance at the size of the medulla will show why. The hair-shaft is practically an empty tube, and can be easily broken.



THE ATTRITIOMETER FOR DETERMINING THE RELATIVE DURABILITY OF DIFFERENT KINDS OF FURS AND FABRICS

What happens when a fur hair is broken can be seen in Figs. 2 and 3. As soon as the protective covering of the cuticle, or outermost integument of the hair-shaft is removed, the fusiform cells composing the cortex begin to fray, or sliver out, and the speedy disintegration of the hair-shaft is the result. In hairs possessing a large medulla this initial break-up occurs much sooner than it does in hairs possessing small medullary columns, or none at all.



TYPICAL MAMMAL FUR-HAIRS, SHOWN IN SECTION AND BY PHOTOMICROGRAPH

Left: Fig. 4. Photomicrograph of a portion of one of the long protective over-hairs of the common gray rabbit, showing proportion of medulla (the large ovoid cells) to cortex. Such a hair breaks more easily than one with smaller medulla. *Center*: Fig. 5. Typical mammal fur-hair, showing structure. It is the cortex element, with its stroug, horny elastic cells, that gives resistance to wear. *Right*: Fig. 6. Two fur-hairs of different wearing qualities, showing how absence of medulla strengthens the hair. At the left we have a fur-hair from the American otter, very durable; at the right one from the European mole, a very weak and easily wearing fur

Most mammals possess two distinct types of hair; a long, rather rigid type, known as the protective, or over-hair, and a shorter, finer, softer, more thickly compacted type, known as the fur, or under-hair. Where the protective hair is left in place, in the make-up of furs, the durability of the fur as a whole is not interfered with. But often this protective hair is removed. A much softer fur is the result. Since, however, the protection of the stiffer hair is no longer present, the wear on the fur hair directly soon makes its effect apparent. Often the protective hair is relatively, and also actually, more resistant to wear than is the fur hair underneath, by reason of its possession of a greater expansion of the cortex element in the shaft. In many other instances, however, the reverse is the case, and the protective hair, while actually more durable than the fur hair, is not relatively so. Fig. 4, taken from a photomicrograph of a portion of the protective, or over-hair, of the common gray rabbit, shows the enormous enlargement of the medullary element in the hair-shaft, and the extremely thin cortex. Such a hair is easily bent and broken. Fig. 1 shows the fur hairs from two common rabbits much used in the fur trade, with their large medullas. Rabbit and hare furs, as one might expect, rank relatively low in the durability scale, always below 10 (otter fur taken always as 100).

There is a slight variation, however, in the resistance character of the cortex in different species of the fur-bearing mammals. This variation is probably due to the quality of the keratin, or horny substance which composes the cortex cells, or to the length of the cells, or to their degree of fusion. It is not sufficient, therefore, in attempting to grade furs on the basis of their durability, to rest content with a microscopic examination alone, though, as has been pointed out, such an examination will reveal much.

FOUR SAMPLES OF FURS MOUNTED ON BLOCKS, READY FOR TEST WITH THE ATTRITIOMETER

In order to determine accurately the resistance of various fur hairs to a wearing process which could be kept constant for each variety of hair, or varied in accurate measure, the writer devised the Attritiometer (wear-measurer) shown on this page. Samples of fur to be tested are taken from various portions of the pelt, and mounted on blocks, as illustrated. These are then clamped in place on the block at the extreme right of the Attritiometer, and in this position are subjected to rubbing backward and forward by horizontal slide, and to beating by the hammer (shown upraised). The force of the blow delivered by the hammer is known (in grams), as is also the weight of the horizontal slide, which is covered with belt-leather of uniform texture throughout. The mechanism is operated by an electric motor (shown at extreme left).

The duration of the test for each sample continues until

the protective hair breaks, and the cortex begins to fray out. This is the initial stage in the disintegration of the hair, and can be conveniently taken as the stage when we can say "wear" begins. The test may be continued until the same stage of disintegration is reached in the fur hair.

In determining the stage at which the test shall be stopped the samples are removed from the Attritiometer and examined under the medium powers of the microscope, by reflected light, *i.e.*, light reflected through the microscopic tube, by the objects under examination themselves, as shown at the left of our opening view. The light must be rather intense, hence the use of the small microscope arc-lamp. For the more careful examination of the individual fur hairs the writer has used the apparatus shown in the right-hand photograph.

From a combination of microscopic examination of the cortex and medulla elements in the structure of the hair-shaft, and of tests of the hairs in the Attritiometer a much clearer idea of the reasons for the durability differences in fur- and fabric-hairs is being acquired. It is now possible to rate the durability of the different fur hairs on an accurate basis.

One of the striking results of Attritiometer tests is the way in which there is shown the superiority of the unclipped over the clipped fur, or over the hairs used in textile work. In the case of the unclipped hair, no portion of the cortex is exposed to wear and to the more rapid disintegration, until after the breaking of the hair occurs, or until some portion of the protecting cuticle is actually worn away. Disintegration, in such a case, then, is much delayed. With the clipped hair, on the contrary, the cortex cells are already exposed, *before actual wear on the hair commences.* Disintegration of such a hair, therefore, begins at once, the cortex fraying, or slivering as shown in Fig. 3 (right).

Tests of furs with the Attritiometer, together with subsequent examination under the microscope, have also shown that the identification of imitation furs can be, in some cases, readily made, on the basis of the different methods of disintegration which different species show. This may prove to be a valuable aid to the methods already described for the identification of mammal hairs under the microscope.

ELECTRICALLY HEATED STEAM BOILERS

THIS subject is ably discussed by Eric A. Lof in the *General Electric Review* for June, 1921, pp. 515-518.

The generation of steam by electric current opens up a new industrial field for utilization of electric power. Its universal use is, however, as yet impossible for economic reasons, but there are many special cases where its application will result not only in a direct economical saving but also in many advantages from an operating standpoint. One particular field where the electric boiler should prove very desirable is in connection with hydroelectric central stations where power can as a rule be obtained at a comparatively low rate and where combustible fuel is generally scarce. When circumstances are such that excess power is available at certain times, generally at night and on holidays, the economic advantages of an electric boiler plant are apparent; and the possibilities of storing up this surplus power or at least part of it as heat in so-called vapor-accumulators offers many new and interesting problems.

From the technical point of view the electric boiler problem in general does not offer any great difficulties, and a large number of such boilers are now in successful operation in all parts of the world. The stock losses of the ordinary boiler are eliminated, and by careful heat insulation the efficiency of the electric boiler may be as high as 96 to 98 per cent. The operating force can be reduced to a minimum, and even when the workmen are poorly qualified the automatic control devices will insure that the normal quantity of steam is continuously obtained under even pressure and without the risk of dry-boiling followed by the liability of explosion which here is quite non-existent. The steam pressure in the boilers can be raised very quickly, in certain cases within as short a time as ten minutes from the moment the current is switched on, a fact of great importance, especially for intermittent working.

The author then calculates the relative heating values of coal and electric heat and arrives at the ratio of $\frac{2.82}{8.5} = 3$. With coal at $5.00 per short ton, the equivalent cost of electric power would have to be not more than 0.085 or less than one-tenth of a cent per kilowatt-hour. This is, of course, only possible in localities where cheap hydroelectric power is available. On the other hand, the cost of fuel may be so high as to make the economical utilization of electric heating look more favorable. The foregoing figures refer of course only to the cost of fuel or power and they do not include the operating and maintenance charges which are very much reduced with the electric boiler. A 100-horsepower electric boiler would be rated 1,000 kw., a 150-horsepower 1,500 kw., etc.

Electric boilers may be classified in two distinct groups: First, such boilers in which the water is heated by means of resistances mounted within the boiler, and, second, such boilers in which the water itself comprises the resistance which is heated when the electric current is passed directly through it from electrodes immersed in it. The author then describes the construction and operation of each type of these boilers. The second type of boiler which is as yet comparatively new in this country, but which is quite universally used in Europe, has electrodes usually of iron, immersed directly into the water and the current is led to them through leads which pass through the boiler cover through steam-tight insulating bushings. The electrodes themselves are often surrounded by cylindrical insulating tubes, which assist the circulation of the water past the electrode. Several such boilers are in operation using electrode voltage of 10,000 volts, and it is said that twice this voltage may be used successfully for the larger sizes. Electrode boilers have been built in capacities up to 4,000 kw., and there would be no difficulty in building them twice this capacity.

A more detailed description of such an electrode boiler installation is given in *Elektrotechnische Zeitschrift* for January 27, 1921, pp. 78-79. It describes the new boiler room of the paper factory at Wargöns in Sweden. The installation consists of seven boilers each designed to take 2,000 kw., and to work at 150 pounds pressure. The electric supply is derived from an overland transmission line which is operated at 10,000 volts. The boilers are cylindrical upright vessels with domed covers through which the electrodes pass into the interior. Nineteen electrodes are arranged in the form of a hexagon within the boiler, and means are provided by which individual electrodes or groups of electrodes, can be cut out as required by the demands for steam.

ROSSI-FOREL SCALE OF EARTHQUAKE INTENSITIES

1. Microseismic shock: recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

2. Extremely feeble shock: recorded by several seismographs of different kinds; felt by a small number of persons at rest.

3. Very feeble shock: felt by several persons at rest; strong enough for the direction or duration to be appreciable.

4. Feeble shock: felt by persons in motion; disturbances of movable objects, doors, windows; crealing of ceilings.

5. Shock of moderate intensity: felt generally by everyone; disturbance of furniture, beds, etc., ringing of swinging bells.

6. Fairly strong shock: general awakening of those asleep; general ringing of house bells; oscillation of chandeliers; stopping of pendulum clocks; visible agitation of trees and shrubs; some startled persons leave their dwellings.

7. Strong shock: overthrow of movable objects; fall of plaster; ringing of church bells; general panic, without damage to buildings.

8. Very strong shock: fall of chimneys, cracks in walls of buildings.

9. Extremely strong shock: partial or total destruction of some buildings.

10. Shock of extreme intensity: great disaster, buildings ruined, disturbance of the strata, fissures in the ground, rockfalls from mountains.

THE EVOLUTION OF CLIMATE IN NORTHWEST EUROPE

By C. E. P. Brooks, M.Sc.

The paper dealt with the period from the maximum of the last (Würmian) glaciation to the present day; this period is divided according to the variations of climate into seven "phases" as follows:

Phase	Climate	Date
1. The Last Great Glaciation	Arctic climate	30,000-18,000 B.C.
2. The Retreat of the Glaciers	Severe continental climate	18,000-6000 B.C.
3. The Continental Phase	Continental climate	6000-4000 B.C.
4. The Maritime Phase	Warm and moist	4000-3000 B.C.
5. The Later Forest Phase	Warm and dry	3000-1800 B.C.
6. The Peat Bog Phase	Cooler and moister	1800 B.C. 300 A.D.
7. The Recent Phase	Becoming drier	300 A.D. onward

These phases were of similar character over the greater part of northern Europe. The chronology is based on the recent work of Baron de Geer in Sweden, which agrees well with that of Penck and Bruckner for the Alps. The reconstruction of the climatology is based chiefly on botanical evidence as to temperature and rainfall, but archæological and purely geological data are also of importance. Each phase was illustrated by a map showing the probable meteorological condition and especially the storm tracks. The idea that geological changes sufficiently marked for recording have taken place in historical times will surprise many.

The last glaciation was a period of arctic climate in Europe with a border of extremely dry easterly winds and almost desert conditions. As the ice-sheet slowly decreased in size the temperature rose, until hot summers were experienced in Germany; but the climate remained dry. The Continental phase corresponds to the *Ancylus* Lake period with cold winters but hot dry summers; this is the first forest period of Scandinavia. The Maritime phase coincides with the subsidence causing the *Litorina* Sea, when the Baltic was more open to the Atlantic than at present; a warm, moist climate prevailed and extensive peat-bogs developed in Europe.

Elevation next caused a decrease in the size of the *Litorina* Sea, and an extension of the area of western Europe; at the same time climate became more continental, and the peat-bogs were replaced by extensive forests. Civilization attained a high level in Scandinavia and Ireland, while there is evidence of sea-borne traffic. This carries us to the beginning of the Bronze Age. The latter was a period of heavy rainfall over the whole North Temperate Zone, causing the weakening of the forests and great development of peat—the Peat-bog phase. About A.D. 300 this passed fairly abruptly into present conditions. The climate changes subsequent to 2000 B.C. are found to agree well with Pettersson's scheme of the variations of the "tide-generating force." Finally, the climatic variations in North America since the Ice Age were investigated, and it was shown that in the Atlantic and Great Lakes region the general sequence was similar to that of Northwest Europe, but the corresponding phases were not always synchronous, and the Later Forest phase was unrepresented. In northwestern North America, where glaciation was much less severe, there was simply a gradual passage to present conditions.—Abstract of a paper read at the Royal Meteorological Society, April 20, 1921.

OCCUPATIONAL DISEASES

Dr. Charles Baskerville has devoted a great deal of study to occupational diseases in the chemical industry and as Chairman of the Committee on Occupational Diseases for the American Chemical Society has made frequent reports of exceptional value. In the *Journal of the Society of Chemical Industry* Dr. Stephen Miall makes some comments on occupational diseases and his remarks which are discussed in an editorial in *Chemical and Metallurgical Engineering* are quoted with the editorial herewith:

"Broadly speaking," he says, "constant exposure to any chemical compound is likely to be injurious to health, particularly if it is likely to give rise to dust, fumes, or gas, and . . . an abundant supply of fresh air is the best method of protecting the health of the workers. . . . All forms of dust and fumes are bad. Constant exposure to coal dust and tar causes what is known as pitch-makers' cancer, tar being the main irritant in this case. The manufacture of marmalade causes injury to the skin by the peeling of oranges and lemons, fine silica dust affects the lungs in a particular way," etc.

Sometimes excellent measures of prevention do not cure, as was the case of prohibition by the Swiss Government in 1879 of the use of yellow phosphorus in making matches. The workers then felt that they could dispense with all precautions where the alleged "harmless" red phosphorus was used, and the poisonings became more frequent than before. It was necessary to alter the law.

Cases of poisoning by carbon monoxide, nitrous fumes and ammonia are increasing in Great Britain, and yet these cases are almost all due to ignorance of the dangerous character of the fumes on the part of the workers. There is no difficult chemical problem in preventing this form of poisoning. A fatal case of benzene poisoning was noted following "improvements" which decreased the ventilation, and an analysis of the air showed two to ten parts of benzene in 10,000 of air. No cases followed after the ventilation was increased.

Turpentine poisoning produces kidney disease and seems to predispose the worker to gout. Persons who are susceptible to the smell of a newly painted room have attributed the illness to white lead or to other causes. It is hardly believable that a volatile lead compound is given off as a gas or emanation from lead paint, and the experience of the past twenty years indicates turpentine as the delinquent.

Autopsies of fatal cases in New South Wales showed in analyses of livers from 0.1 to 0.9 grains of cadmium per pound with merely a trace of lead. Dr. Miall believed these occurred in the zinc-smelting industry of that region. The symptoms of cadmium poisoning include kidney disease, constipation and loss of appetite. Zinc is a general protoplasmic poisoning and in the higher animals it causes muscular contraction and kidney disease. Copper, tin, nickel and manganese have injurious properties, but cases of poisoning by them are rare.'

"White lead has been a fruitful producer of disease. About thirty years ago there were many preventable cases of lead poisoning in Great Britain, amounting in the white lead industry itself to about 400 cases a year, in making china and earthenware 200 cases and in printing, glass, shipbuilding and other industries about 400 more, making over 1,000 in all. Restrictions as to improper use, removal of dust, substitution of an insoluble lead silicate for white lead in the glazes of china and earthenware, rules for wearing overalls, etc., have caused a steady decline. Indeed the number of cases has decreased from over 1,000 cases annually to eleven cases in 1898 and twenty-one in 1919. It is said that lead poisoning is not caused by particles of lead swallowed by the worker, but rather by even more minute particles floating in the air inhaled into the lungs and so getting into the system. The headache complained of by painters is more likely to be caused by turpentine than lead. Diagnosis is difficult, and poisoning by cadmium, turpentine, arsenite of copper and other agents is often erroneously classed as due to lead."

Nitrogen in the Arts and Industries

A Survey of the Part It Plays in Modern Economics, and the Sources of Supply

By George W. Phillips and J. Norman Taylor

THE need for combined nitrogen to supply the ever-increasing requirements of agriculture has been widely felt for many years past. In 1898 Sir William Crookes[1] in his famous address before the British Association for the Advancement of Science pointed out the necessity of increasing the wheat production by the application of fertilizers. He stated that unless the average world-yield of wheat—at that time 12.7 bushels to the acre—were increased through soil fertilization, there would be "just enough to supply the increase of population among bread-eaters till the year 1931. . . . If bread fails—not only us, but all the bread-eaters of the world—what are we to do? We are born wheat-eaters. Other races, vastly superior to us in numbers, but differing widely in material and intellectual progress, are eaters of Indian corn, rice, millet, and other grains; but none of these have the food value, the concentrated health-sustaining power of wheat, and it is on this account that the accumulated experience of civilized mankind has set wheat apart as the fit and proper food for the development of muscle and brain."

The consumption of nitrogenous substances for agricultural purposes rapidly increased until in 1905[2] nearly two million tons, not including cottonseed meal, were being used in the United States alone and estimates for 1919[3] show the consumption of fertilizers to be in the neighborhood of 7,500,000 tons. The demand for nitrogen in forms available for agricultural purposes is constantly growing and the problem of supplying the demand very fast becoming one of importance to the nation. As recently pointed out by Cameron[4] the intensive management of the soil for the cultivation of crop plants is still imperative upon this country, and an increased efficiency of yield may be brought about through the use of fertilizers.

The need of large amounts of nitric acid and of ammonia for the production of munitions necessary for the national defense, of explosives for use in mining and engineering operations, and for many other uses in the arts and the chemical industries is also an ever-increasing one which is growing by leaps and bounds.

Although the need for national independence in this regard was brought home to us with great force only through the advent of war, the importance of an adequate supply of nitrogen compounds was clearly recognized by Munroe[5] in 1909, at a time when the military demand was not generally apparent and had not been previously recognized. In concluding his address before the United States Naval Institute in that year and presupposing the erection in this country of nitrogen fixation plants, he said: "From this account of recent chemical progress it is evident that it is possible to conduct a prolonged war without robbing the soil on which the people depend for food of its fertility, and further, that, notwithstanding the enormous and constantly increasing demand for nitrogen compounds in agriculture and manufacture, this country has reached a potential degree of independence, as regards its supply of nitrogen compounds for military uses, such as it never before enjoyed, so that it needs hereafter to consider foreign sources of supply only from the economic standpoint. However, I desire to say regarding the plants for the fixation of nitrogen what I have repeatedly advised regarding plants for the manufacture of explosives, viz., that it is a wise policy for our Government to foster, and in a measure supervise, these manufacturing operations, and to look to it that plants for these purposes are so strategically located throughout the country as to be reasonably well protected from attack, so that they may serve the military establishment in case of foreign invasion from any quarter or of internal uprisings in any locality."

The importance of nitrogen in the national economy is evident for "history shows that every nation which has disappeared out of the civilization of the world went out by one or the other of two courses: It was either vanquished or destroyed by military processes, or it exhausted its soil and had to move."[6]

The nitrogen compounds needful for use in agriculture, for the manufacture of explosives and for use in the arts and the chemical industries are obtained from a variety of sources.

Certain plant orders,[7 8 9 10] notably the leguminosæ, through the agency of bacterial growths which form nodules on the roots of such plants, have the power of taking nitrogen from the air and so fixing it that it becomes available for food for vegetation. The employment of the legumes and other nitrogen fixing plants in the rotation of crops,[11] therefore constitutes a valuable means of enriching the soil. Other plants obtain their nitrogen from such soil and then animals are nourished by the nitrogenous substances contained in these plants. Upon the decay of animal and vegetable matter, part of the combined nitrogen which they contain is, through the action of nitrifying bacteria, returned to the soil in the form of nitrates and of ammonia, but a large part of this nitrogen, however, is set free and returns to the atmosphere as nitrogen gas, and thus a cycle of nitrogen in nature is maintained on an enormous scale.

The nitrogen compounds obtained as by-products in the gas industry and from the by-product coke ovens are the result of nitrogen fixation effected ages ago by prehistoric plant life.

Another natural method of nitrogen fixation, which must take place on a very large scale, is that which is brought about through silent electric discharges constantly occurring in the atmosphere. The passage of the electricity through the air causes the nitrogen and oxygen atoms to unite with the consequent formation of nitric oxide. This in turn is oxidized to the higher oxides of nitrogen which are carried into the soil by rains and snows where they form salts by interaction with the naturally occurring basic substances.

The world's chief source of native nitrates, the Chile nitrate beds, although of somewhat doubtful origin,[12] and produced

[1]Report of the Sixty-eighth Meeting of the British Association for the Advancement of Science at Bristol in September, 1898.

[2]Munrot, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Washington, Government Printing Office, 1908.

[3]Gaillard, Maj. D. P., Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[4]Cameron, Frank K., The Outlook for the Fertilizer Industry. *Chem. and Met. Eng.*, Vol. 24, No. 1, p. 9. 1921.

[5]Munroe, Charles E., The Nitrogen Question from the Military Standpoint. Proceedings United States Naval Institute, Vol. 35, No. 3, 1909.

[6]Secretary Baker before the Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[7]Wiley, Principles and Practice of Agricultural Analysis.

[8]Merrill, George P., Rocks, Rock-Weathering and Soils: The MacMillan Company, New York, 1897, p. 203.

[9]Coulter, John M., Plant Structures: D. Appleton & Co., New York, 1904, p. 89.

[10]Kellerman, Karl F., Nitrogen Gathering Plants: Year Book, U. S. Department of Agriculture, Government Printing Office, Washington, 1910, pp. 213-218.

[11]Morse, W. J., Cowpeas Utilization: Farmers' Bulletin 1153, United States Department of Agriculture, Washington, 1920.

[12]Clarke, F. W., The Data of Geochemistry, Bulletin 695, Fourth Edition, Washington, Government Printing Office, 1920, p. 253.

probably to an extent by the process just described, is supposed to have been chiefly formed as a result of the accumulation of guano deposits which subsequently decomposed with the formation of sodium nitrate and other salts.[13]

The Chile deposits, together with the limited India deposits of potassium nitrate, constituted the main source of supply of combined nitrogen for all purposes until production by artificial means was stimulated through necessity.

Munroe[14] found that the consumption of nitrate of soda in this country alone increased about 40 per cent between 1900 and 1905. "During the World War the United States was absolutely dependent upon imported Chilean nitrate to supply over 75 per cent of its inorganic nitrogen demand, and imported during 1918 some 2,000,000 tons of nitrate, or two-thirds of the entire Chilean production."[15] The Chile deposits cover an area of over 400 square miles, a small portion being in Peru and Bolivia. The crude material, known as "caliche," is crushed and treated with boiling water, dissolving the crude nitrate. After settling, the liquor containing the nitrate is subjected to evaporation and crystals containing 95 per cent of sodium nitrate are so obtained. Comprehensive reports of the Chile saltpeter industry from the economic standpoint as well as the statistical, are given by Norton[16] and by Fisher.[17]

Utilization of the Chilean nitrates for the production of ammonium nitrate without the intervention of sulphuric acid was brought about during the war.[18] The process was devised by Freeth and Cocksedge[19] and is based on the metathetical reaction between sodium nitrate and ammonium sulfate. The reaction occurs in solution and is a reversible one, equilibrium in the distribution of the salts being reached in accordance with the law of mass action. A process first developed in France for the manufacture of ammonium chloride by the utilization through interaction of waste products from the Haber ammonia and the Solvay soda processes has recently been introduced in England and this country[20] as a new means of nitrogen fixation, but the Chile nitrate beds will long continue to be the source of a large part of the world's supply of *concentrated* nitric acid. This acid was known to the alchemists and was prepared by Geber in the ninth century by a process similar to that of the present time.

The successful commercial production of *dilute* nitric acid is accomplished by the arc process of atmospheric nitrogen fixation. Franklin[21] estimates that the amount of nitrogen in the atmosphere is equal to about 4041 x $(10)^{15}$ tons, assuming that the air over each acre of the surface of the earth contains 31,000 tons of nitrogen. It is however free. As Slosson[22] humorously says "That is the trouble: it is too free. It is fixed nitrogen that we want."

That the action of the electric spark in passing through air produces compounds of nitrogen was noted by Priestly in 1775. Later Cavendish, whose researches laid the foundation for much subsequent work in the gases, prepared potassium nitrate from the nitrogen compounds obtained in this way. Berthollet, in the course of his investigations of explosives, observed such fixation but apparently no attempt was made to develop Cavendish's discovery into a commercial operation until, as a result of the work of Bradley and Lovejoy, and following the granting of their patent in 1902, a plant was erected at Niagara Falls for the production of nitric acid by the arc process, but it failed of commercial success owing to economic conditions, as well as to the character of the arcs used, and this plant was abandoned.

In Norway, a few years later, Birkeland and Eyde established a plant also using the arc process and this plant proved commercially successful because the current could be obtained cheaply from the abundant water power at hand and because of the modification in the character of the arc used, this being a flaming arc drawn out by powerful magnets through which the air was forced in a tangential direction. The later invented Schoenherr and Pauling furnaces are still more efficient than the Birkeland-Eyde for through the spiral motion imparted to the flaming arc used, a greater amount of air is exposed to the heat of the arc. It appears, however, that before arc processes can compete with the other processes of atmospheric nitrogen fixation much investigational work remains to be done. "Even the most fundamental data on arcs, and particularly the transient arcs used in nitrification, are very little known and uncertain, and it appears that the possibilities of development are much greater with the arc process than with any other nitrification process."[23]

Other important methods[24] [25] of nitrogen fixation are the cyanamide process, the nitride and cyanide processes, and the ammonia process wherein elemental nitrogen and hydrogen are combined directly as in the Haber process. At the present time conditions are in favor of nitrogen fixation through the formation of ammonia. The ammoniates are the more desirable forms of nitrogenous compounds for use as fertilizers and should an emergency demand it ammonia can be oxidized to nitric acid. In his paper before the Washington Section of the American Chemical Society, May 8, 1919, Parsons[26] spoke of the development and application of Ostwald's process for doing this and gave a detailed account of the commercial oxidation of ammonia to nitric acid. Nitrogenous products of organic origin are a source of ammonia compounds and have been much used as a basis for the manufacture of fertilizer but most of these organic substances, such as tankage and dried blood from the packing houses, fish scraps, and cottonseed meal are now being diverted from use in manufactured fertilizers and used as stock feeds for which they command a higher price. Practically the whole supply of ammonia and its compounds was obtained, until recently, as a by-product of coke ovens, and, in a smaller degree, from other operations involving pyrolytic distillation, such as gas works, blast furnaces and boneblack factories. In 1905 there were produced in the United States from the by-product coke industry 15,773 tons[27] of ammonium sulfate, while the total amount of all ammonium compounds recovered from by-product coke plants amounted to only 30,317 tons,[28] necessitating, as demands increased, the importation of ammonium salts. The need for increasing the output of ammonia and its salts was shown in 1912 in the comprehensive report by Munroe[29] on the gas industry in the United States, in which it appears that between 1900 and 1909 the imports for consumption of ammonium

[13] Merrill, George P., Rocks, Rock-Weathering and Soils: The Mac-Millan Company, New York, 1897, p. 373.

[14] Munroe, Charles E., The Consumption of Nitrate of Soda in the United States: *Jour. Ind. and Eng. Chem.*, Vol. 1, No. 5, May, 1909.

[15] Burns, Col. J. H., Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congrtss, 1920.

[16] Norton, T. H., Consular Report on Utilization of Atmospheric Nitrogen: Washington, 1912.

[17] Fisher, Herman Edward, Lieut. Commander, U. S. Navy, The Nitrogen Industry: *Jour. Franklin Inst.*, August, 1920, pp. 187-209.

[18] The United States Ammonium Nitrate Plant, Perryville, Md. (Atlas Powder Co.) *Chem. and Met. Eng.*, Vol. 20, No. 7, p. 320, 1919.

[19] U. S. Patent, 1,051,097 — 1913.

[20] A Significant Combination. Editorial in *Jour. Ind. and Eng. Chem.*, Vol. 12, No. 2, p. 107, 1920.

[21] Franklin, Milton W., The Fixation of Atmospheric Nitrogen: *The Chemical Engineer*, Vol. 14, No. 5, p. 453, 1911. From the *General Electric Review*.

[22] Slossen, Edwin E., Nitrogen: Preserver and Destroyer of Life: *The Independent*, Vol. 92, No. 3593, Oct. 13, 1917, p. 93.

[23] Steinmetz, Charles P., Theoretical Study of Nitrogen Fixation by the Electric Arc: *Chem. and Met. Eng.*, Vol. 22, No. 7, p. 300, 1920.

[24] See report on the nitrogen industry by Charles L. Parsons in the *Jour. Ind. and Eng. Chem.* for September, 1917, Vol. 9, No. 9.

[25] See address of Alfred H. White, Lt. Colonel, U. S. Army, The Present Status of Nitrogen Fixation: published in *Jour. Ind. and Eng. Chem.*, Vol. 11, No. 3, 1919, p. 231 et seq.

[26] Parsons, Charles L., Commercial Oxidation of Ammonia to Nitric Acid: *Jour. Ind. and Eng. Chem.*, Vol. 11, No. 6, pp. 541-552.

[27] Munroe, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Government Printing Office, Washington, 1908.

[28] Munroe, Charles E., Coke Census of Manufactures: 1905, Washington, Government Printing Office, 1907.

[29] Munroe, Charles E., The Gas Industry in the United States, 1909: Press of *Progressive Age*, New York, 1912.

sulfate increased from 16,822,000 pounds to 79,453,025 pounds; for the carbonate from 298,778 pounds to 414,683 pounds; and of ammonium chloride from 5,065,057 pounds to 7,575,483 pounds. General Williams,[30] in testimony before the Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, said that, although the production of fixed nitrogen had been increased mainly through the construction of by-product coke ovens, we were in 1916 "still some 75 to 80 per cent dependent upon importation." It is to be noted[31] that Germany has declared her independence in the matter of nitrogen importation.

At the present time large quantities of ammonia are being produced by synthesis. As noted above, the synthetic methods consist either in the direct union of nitrogen with hydrogen to produce ammonia directly or in the production of cyanamid, nitrides, or cyanides to produce ammonia indirectly.

The direct synthesis of ammonia, whereby elemental nitrogen and hydrogen are caused to combine, was developed through the studies of Haber. In principle, nitrogen and hydrogen in a high state of purity, are caused to combine through the influence of a catalyzer and under pressure, the reaction occurring according to the following equation:

$$N_2 + 3H_2 \rightleftarrows 2NH_3$$

Although at first glance the operation appears to be a very cheap and simple one, the conditions obtaining cause the process to be both expensive and difficult. In the process now in use, the hydrogen is obtained through the decomposition of water by the action of carbon and requires a great expenditure of coal or coke as well as an enormous amount of energy. Also, owing to the great disinclination of nitrogen to enter into combination with hydrogen, our present knowledge requires the operation to be conducted at an exceedingly high temperature and under great pressure, and, as the reaction is a reversible one, the most favorable conditions produce only a 5 per cent yield. A more extended and successful application of this process is dependent upon its perfection by our investigators.

Ammonia is prepared from cyanamide by passing superheated steam over it, when the reaction, represented by the following equation, takes place:

$$CaCN_2 + 3\ H_2O \rightarrow CaCO_3 + 2\ NH_3$$

The cyanamide process for the fixation of atmospheric nitrogen was invented by Frank and Caro and today is the most important of the fixation processes. The product can easily be converted into ammonia, which in turn is readily oxidizable to nitric acid. Cyanamide is itself directly applicable as a fertilizer, as all of its nitrogen is available as plant food, and from it descends a whole family of useful nitrogen-containing products.

The first investigation of the cyanamide process in the United States was made by Munroe[32] in 1907 and in the same year "an experimental plant of commercial size was built in Canada at Niagara Falls where the cheapest available power was to be had."[33] Three years later (1910) the first product was delivered to the consumer.[34]

The industrial importance of the cyanamide process was early noted and emphasized by Munroe[35] who pointed out in 1907 that "in this" (the Frank and Caro process) "is found a practical and economical process for the fixation of atmospheric nitrogen, a further use for calcium carbide, and a valuable and very extensive field for the utilization of liquid air; while the product itself is a valuable fertilizer, which may be used directly as such. Furthermore, by very simple means a considerable number of useful chemicals may be produced from it, among which may be mentioned potassium and other cyanides, ammonia and ammonium sulfate or other ammoniacal salts, urea, guanidin, dicyanamide, and nitric acid."

In 1917, at the invitation of our Government, a plant for the fixation of nitrogen by this process was started at Muscle Shoals, Alabama. It was purposed to construct a plant of sufficient size to supply the nitrogen compounds necessary for the national defense and, in peace time, for agricultural purposes. A description of the Muscle Shoals plant by Fairlee[36] gives a detailed account of the methods used in this plant. Essentially, the cyanamide process consists in the union at a high temperature of nitrogen with calcium carbide in accordance with the equation

$$CaC_2 + N_2 \rightarrow CaCN_2 + C$$

The product is known as lime-nitrogen, or nitro-lim, and it contains about 60 per cent of cyanamide.

An important process for the production of ammonia and one which gives promise of greater application is the Serpek[37] process which involves the use of aluminum nitride. Beauxite and carbon are heated in an atmosphere of nitrogen at a temperature of about 1800° C., when nitrogen is absorbed as follows:

$$Al_2O_3 + 3C + N_2 \rightarrow 2\ AlN + 3\ CO$$

The aluminum nitride thus formed is decomposed by caustic soda with the formation of ammonia

$$AlN + 3NaOH \rightarrow NH_3 + Na_3AlO_3$$

Another process for the fixation of atmospheric nitrogen which has attracted considerable attention and which has recently been given industrial application is the Bucher[38] process for the production of cyanides. In this process, nitrogen is passed over a red hot mixture of sodium carbonate and coke contained in a twenty-foot tube and in contact with finely divided iron which acts as a catalytic agent, whereupon the reaction proceeds according to the equation

$$Na_2CO_3 + 4C + N_2 \rightarrow 2NaCN + 3CO$$

Ammonia may be prepared by further treatment of the cyanide and the resulting sodium carbonate again used in the process.

Recent researches on methods of activating nitrogen, excellently epitomized by Anderegg[39] in a paper in which he reviews the work done by Lewis, Strutt, Grubb and Wendt, and others, promise to be of great value in overcoming the many difficulties experienced in nitrogen fixation. This very inertness of nitrogen, its reluctance to enter into combination with other elements, is a property which makes it peculiarly adapted for use as a constituent of explosives because of its efforts to become free again. The almost instantaneous evolution of large quantities of gas and heat on explosion gives rise to a tremendous driving power. Nitroglycerine, for example, upon explosion, liberates 1300 volumes of gas from one volume of the substance, and the heat of the reaction expands it to over 10,000 volumes.

Black gunpowder, nitroglycerine, nitrocellulose, and trinitrotoluene are the most common of the manufactured explosives. These may be said to represent four general classes of explosives.

[30]Williams, Maj. Gen. Clarence, Testimony before Senate Committee on Agriculture and Forestry relative to the production of atmospheric nitrogen, Sixty-sixth Congress, 1920.

[31]Caro, N. Prof., The German Nitrogen Syndicate: *Chem. and Met. Eng.*, Vol. 22, No. 15, p. 686. Translation from *Chemische Industrie*, Nos. 13 and 14, July, 1919, by Arthur B. Lamb.

[32]Munroe, Charles E., Report on Calcium Cyanamid (lime nitrogen), New York, 1907.

[33]Testimony of Frank S. Washburn relative to the production of atmospheric nitrogen, before Senate Committee on Agriculture and Forestry: Sixty-sixth Congress, 1920.

[34]A description of the cyanamide process for nitrogen fixation was given by W. S. Landis in an address, "The Fixation of Atmospheric Nitrogen," published in the *Jour. Ind. and Eng. Chem.*, Vol. 7, No. 5, pp. 433-38, 1915.

[35]Munroe, Charles E., Chemicals and Allied Products, Bulletin 92, Census of Manufactures: 1905, Washington, Government Printing Office, 1908.

[36]Fairlee, Andrew M., Muscle Shoals Nitrate Plant: *Chem. Met. Eng.*, Vol. 20, No. 1, pp. 8- , 1920.

[37]A description of the Serpek process for nitrogen fixation is given by Samuel A. Tucker in the *Jour. Soc. Chem. Ind.*, Vol. 32, No. 24, pp 1143-4, 1913.

[38]Bucher, John E., The Fixation of Nitrogen: *Jour. Ind. and Eng. Chem.*, Vol. 9, No. 3, pp. 233-53, 1917.

[39]Anderegg, F. O., Activated Nitrogen: *School Science and Mathematics*, Vol. 20, No. 7, pp. 571-6, 1920.

Gunpowder was probably invented by the Chinese, but it was not until the thirteenth century that it was used in warfare. Since less than 50 per cent of the products of black gunpowder are gases, it is not comparatively a powerful explosive and has been superseded by more powerful ones. It is essentially a mixture of 75 per cent saltpeter, 10 per cent sulfur, and 15 per cent charcoal and is extensively used for sporting purposes and for mining and blasting. The variety of industrial and commercial uses to which explosives are put is described by Munroe[40, 41] and by Munroe and Howell[42, 43]. In a recent bulletin, Munroe[44] also calls attention to the outrages with explosives and the necessity for their control.

By the action of nitric acid on glycerine, in the presence of sulfuric acid which acts as a dehydrating agent, nitroglycerine is formed. It consists chiefly of glycerol nitrate. Modern methods of manufacture are but a development of Nobel's original process. It is a much more powerful explosive than black gunpowder and is very unstable. Nobel stabilized it by incorporating it with kieselguhr, giving it the name of dynamite, but most of our present day dynamites are mixtures of nitroglycerine with sodium nitrate and wood pulp and a small amount of calcium carbonate, which serves as the stabilizing agent by preventing acidity. It is employed in increasing quantities in mining, quarrying, the planting of trees, for digging ditches and foundations, in fighting conflagrations, in breaking ice jams, and in many engineering operations.

The development of explosives has been rapid. Knowledge regarding them advanced and other storehouses of energy were developed by the nitration processes. Nitrocellulose, an essential constituent of smokeless powder, is made by the action of nitric acid on cellulose, or purified cotton, in an analogous manner to that employed in the nitration of glycerine. It resembles cotton in appearance and when not confined burns rapidly but quietly when ignited. Through the use of a detonating primer, in the form of gun cotton, it releases its energy with enormous rapidity and violence. When nitrocellulose is to be used in smokeless powder its rate of energy release is lessened by forming it into a plastic mass with alcohol and ether and molding the mass, while plastic, into preferred shaped grains. Ballistite, another form of smokeless powder, is formed upon dissolving nitrocellulose in nitroglycerine. The U. S. Army has now abandoned the nitroglycerine-nitrocellulose powder and has adopted a straight nitrocellulose powder of definite nitrogen content, approaching more closely to the principle enunciated by Munroe that the ideal smokeless powder "should be composed of a single chemical substance in a state of chemical purity."

"The invention and introduction of safety powders has gone on rapidly abroad, and to a more moderate extent in this country, since the census of 1900 was taken. Since, through the researches in France, it was shown that ammonium nitrate diminished the temperature of the products of explosion and tended to render explosives containing it safe for use in fiery mines, the ammonia powders have had a marked increase in popularity. In the last edition of his book Guttman[45] gives two tabular lists of modern explosives for use in mines, one of "nitroglycerin safety explosives" and one of "ammonium nitrate and other explosives." In the first list there are enumerated 23 different explosives containing ammonium nitrate, of which grisoutine A contains as much as 90.45 per cent of this substance, while in the second list there are 38 different powders containing ammonium nitrate, one of these, ammonal, being composed of 95 per cent of ammonium nitrate and 5 per cent of powdered aluminum."[46]

"The Austrian artillery appears to have tentatively used the mixture of ammonium nitrate and aluminum known as ammonal, but the sensitiveness to percussion and friction of explosives having an aluminum base appears to have led to its discontinuance."[47]

Smokeless powders are variously named, depending upon their composition and the country in which they are produced. For instance, the chief English smokeless powder is known as cordite. The first smokeless powder adopted by the United States Navy for use in the large guns, which was invented by Munroe, was called indurite, the German powder is called ballistite, and the Italian product is known as solenite.

The principal "high explosives" manufactured in this country for military use are divided, according to Wright,[48] into (1) nitrated aromatic compounds and (2) nonaromatic explosives. In connection with the World War several new high explosives of the nitrated aromatic class were developed. Among them, trinitrotoluene, prepared by the nitration of toluene, was the most widely used. It is known under a number of names — T. N. T., tolite, trotyl, trinol and trilite. Picric acid, trinitrophenol, is also designated by a variety of names. In France it is known as "melinite," the British call it "lyddite," and the name given to it in Japan is "shimose."

Other nitro-aromatic compounds used as explosives are trinitroxylene, or T. N. X., trinitrocresol, and the nitrated anilines. A mixture of ammonium nitrate and T. N. T. was employed in the war to meet the enormous demands for bursting charges, and was known as amatol.

As in other branches of chemical industry, progress in the explosives industry during the past several years has been along the lines of improvements in processes of manufacture and of scientific control. New methods of nitration are being devised as well as studies made of the action of catalysts upon the reactions involved in manufacture. The lines of research on the stability of the finished products under various conditions have been broadened and it is interesting to note the observations of Custis,[49] who, working in this laboratory, found that light, especially ultra violet light, had a marked effect on trinitrotoluene, causing its decomposition to an extent that was easily shown not only by a change in color, but by a lowering of the melting point.

The many applications of the lower nitrated cellulose products, the pyroxylines, has given rise to the imitation ivory industry. Collodion, a solution of pyroxylin in ether and alcohol, has a restricted employment in surgery and is largely used in the manufacture of photographic films and plates, making possible modern photography with all of its remarkable applications. Due to their diminished inflammability, the cellulose acetates are taking the place of the nitrates in the manufacture of motion picture films. Collodions are used also for lacquers in the waterproofing of cloths and in the manufacture of artificial leather for use in making belts, bags, shoes, in book binding, in the manufacture of automobile upholstery, and of other artificial fabrics. Nitrated cellulose is the basis of one of the early French processes for the production of artificial silk.

[40]Munroe, Charles E., The Application of Explosives: *Popular Science Monthly*, Vol. 56, pp. 444-455, 1900.

[41]Munroe, Charles E., Explosives for Use in Industrial and Commercial Developments, a paper presented before the Second Pan-American Scientific Congress, Washington, U. S. A., December 27, 1915-January 8, 1916.

[42]Munroe, Charles E., and Howell, Spencer P., TNT as a Blasting Explosive: United States Department of Agriculture, Department Circular 94, Washington, Government Printing Office, May, 1920.

[43]Munroe, Charles E., and Howell, Spencer P., Picric Acid as a Blasting Agent: United States Department of the Interior, Bureau of Mines Serial No. 2243, Reports of Investigations, Washington, April, 1921.

[44]Munroe, Charles E., Regulation of Explosives in the United States: United States Department of the Interior, Bureau of Mines Bulletin 198, Washington, Government Printing Office, February, 1921.

[45]Oscar Guttman, Handbuch der sprengarbeit, Braunschweig, 1906.

[46]Munroe, Charles F., Chemicals and Allied Products, Bulletin 92, Census of Manufactures, 1905; Government Printing Office, Washington, 1907.

[47]Commandant A. R., Projectiles Containing Explosives. Translated from *Revue Generale des Sciences Pures et Appliques*, Vol. 27, pp. 213-221, by Charles E. Munroe, 1916.

[48]Wright, Carleton H., Lieut. Commander, U. S. Navy, American Production of Military High Explosives and Their Raw Materials: United States Naval Proceedings, Vol. 46, No. 10, pp. 1567-81, 1920.

[49]Custis, Horace H., Studies in Actinochemistry: *Jour. Frank. Inst.*, Vol. 184, No. 6, p. 877, 1917.

The incorporation of camphor with the lower nitrated cellulose gives rise to celluloid,[50] a substance widely used in the arts. The manufacture of celluloid and its fashioning into a great variety of articles constitutes an important industry.

The cyanides are used primarily in the extraction of precious metals from their ores. Their extremely poisonous character is emphasized by a recently published newspaper account,[51] attributing a number of deaths in a mining center in Mexico to the swallowing of water used in the chemical treatment of ores. Included in the cyanides are the ferro- and ferri-cyanides, Prussian blue, Paris blue, and Turnbull's blue, the cyanates, and the sulfocyanates (thiocyanates or sulfocyanides), all of which are largely used in the arts and industries.

Of the ammonia produced in the United States, approximately a fourth is used in refrigeration and for ice manufacture and about a third in the chemical industries for the manufacture of soda ash and various ammonium salts, while the remainder is consumed for miscellaneous purposes.

Many of the dyes are nitrogen-containing substances, and their manufacture involves the use of large quantities of nitric acid and other nitrogen compounds, while the manufacturing processes involved in their production and the potential value of the equipment of this industry in time of war makes them especially worthy of mention in this connection. The dyestuff industry is recognized as a growing and important one. The advantage of securely establishing an American dye industry, the necessity for researches in dyestuffs, and the relationship of the dyestuff plant to the explosives industry is detailed by Rose[52] in his recent brochure.

DETERMINATION OF ELECTRICAL EQUIPMENT FOR A MINE HOIST

By GRAHAM BRIGHT

THE rapid increase in reliability, the low cost of operation, the ready application of safety devices, and the growing availability of central-station power have made the question of installing a hoist of the electric type no longer debatable. Where adequate electric power is available, there are few cases where it would be advisable to install a steam or air hoist.

The type of electrical equipment depends largely on the nature of the power supply, its capacity, and the form of the contract under which power is purchased. In a large majority of cases, the available electric power is alternating current, three phase, 60 cycles. There is, however, considerable 25-cycle power in use; and in a few instances constant voltage direct current is the only power available for a small or an occasional medium-size hoist.

Where a new hoist is to be installed, the designer of the mechanical parts can readily take care of the maximum stresses likely to be imposed by the motor. Where the hoist is already installed and operated by steam or air and it is desired to substitute an electric motor for the engine, a careful check should be made to determine the advisability of using the old mechanical parts. In most cases it is better to install a complete new hoist than to attempt to use old mechanical parts. A steam engine has a definite maximum torque, which the hoist has been designed to withstand, while a motor may be able to deliver momentary torques beyond the strength of the mechanical parts of the hoist.

The selection of the proper type of electrical equipment can only be made after complete information is obtained and certain calculations made to determine the capacities required. There are several methods used in making hoist calculations, but no matter what method is utilized a fair degree of familiarity with hoists and hoisting conditions is necessary before an intelligent analysis and proper selection can be made.

Some of the hoist calculation methods are long and complicated. Where such calculations are seldom made, it is better to use the longer methods; but where the calculations are made daily, shortcuts can often be used to great advantage. Engineers associated with the writer, during the last few years, have felt that the various shortcut methods that had been worked up could be assembled in such a manner that any engineer working on hoisting problems could complete the necessary calculations in a short time and the results could be easily checked by another engineer. With this end in view, forms were evolved so that it was only necessary to fill in blank spaces to make a complete set of hoist calculations. These forms have been modified from time to time in accordance with suggestions by various engineers. At the top of the form is place for the name of the customer, filing information, the date, and the characteristics of the power system. Under the heading General Data are the specifications or the information necessary before calculations can be made. This is followed by the various steps necessary to obtain the complete hoisting cycle, which require only calculations of a fairly simple character. As many of the conditions of operation cannot be approximated more closely than 3 to 5 per cent, all calculations can be made by use of the slide rule.

In order to better illustrate the value of the method, examples are given showing the determination of the electrical equipment of an alternating current hoist, a direct current hoist with flywheel motor generator set, and a direct current hoist with a synchronous motor generator set. The forms are so arranged that a single sheet 8½ by 11 in. is required for the complete calculations of an alternating current hoist and but two sheets are required for either of the direct current hoists. In the typical case selected, the hoist is of the vertical type using self-dumping cages.—From paper to be presented at Wilkes-Barre Meeting, Am. Inst. Min. and Met. Eng.

THE ACTION OF SEA WATER ON TEXTILE FABRICS

CHARLES DORÉE in the *Color Trade Journal* for May discusses the action of sea water on cotton and other textile fabrics. Examinations were made of twelve samples as follows:

Cotton fabric;
Cotton fabric treated spermaceti;
Cotton fabric treated spermaceti and ironed;
Cotton fabric tanned with cutch;
Linen fabric;
Linen fabric treated spermaceti and ironed;
Linen fabric tanned with cutch;
Worsted fabric;
Worsted fabric tanned valex;
Silk fabric;
Silk fabric treated spermaceti;
Viscose silk.

The chemical changes produced in cellulose by the action of sea water and the influence of oxygen, light and bacteria are discussed. Without going into these details for which the reader would do better to refer to the original article, this interesting summary is given:

"1. Fabrics of cotton and silk are destroyed by immersion in sea water for three weeks, wool lasting somewhat longer;

"2. This destructive action has been shown in the case of cellulose to be due to micro-organisms and not to oxygen, light or the salts present;

"3. In its nature it resembles the 'mechanical' break-down of cotton sometimes observed under the 'beetling' process;

"4. If cotton is acetylated to the monoacetate stage so that is structural qualities are preserved, the resulting material is very resistant to sea water;

"5. Cellulose acetate silk now manufactured on a large scale has proved able to withstand the action of sea water for months."

[50]A review of the Celluloid Industry by F. Sproxton, in which the development of the industry and the manufacture and employment of the product are treated, is to be found in the *Jour. Soc. Chem. Ind.*, Vol. 39, No. 20, 1920.

[51]*The Washington Post*, January 20, 1921.

[52]Rose, Robert E., Molecules and Man: E. I. DuPont de Nemours & Co., Wilmington, 1920.

Making Various Objects from Gelatine*

Some of the Commercial Applications of This Interesting Substance

By P. Hoffmann

MANY articles of commercial importance can be made from gelatine or glue. Perhaps, the most familiar of these is the gelatine capsule used in medicine for doses of drugs with a very disagreeable taste. A great many other articles are made from gelatine, but the nature of the substance is often changed so greatly by the process of manufacture that the layman is deceived entirely, and cannot tell whether the article is made of gelatine or not. A few of the most important of these objects are tubes, piping, balls, artificial fruits, pearls or beads, so-called stones (gems), glass substitutes, etc.

In many cases the gelatine is used pure. Sometimes it is colored. Very often the gelatine is mixed with asbestos, glycerine, chalk, talc and other similar substances of the kind that are used in compounding rubber. Gelatine is soluble in water, and when the manufactured article must come in contact with water, the gelatine is made waterproof by treatment with formaldehyde.

Gelatine is bought generally in the form of sheets.[1] If the article can be made directly from the sheet, no other treatment is necessary. Otherwise, the gelatine is dissolved in water or else made plastic or fluid by the application of heat.

TUBES

Tubes of gelatine are made by dipping wires or rods of various diameters into the melted substance. A coating is formed on the mold and after the latter has been drawn out of the gelatine bath, the gelatine tube can be stripped off. This is, of course, possible only if the gelatine does not stick to the mold. To prevent this from happening, the wires or rods are smeared with a little grease, but when the gelatine tubes must be absolutely pure, it is necessary to put the tubes through a cleaning process to remove the grease.

Fig. 1 represents diagrammatically the essential features of an apparatus invented by E. Weil, which eliminates this disadvantage. The parallel tubular molds are made of copper. These tubes are fastened into a header, 2, which is hollow and is provided with a water inlet tube, 3. The apparatus is submerged in the gelatine bath, 4, and a coating of gelatine

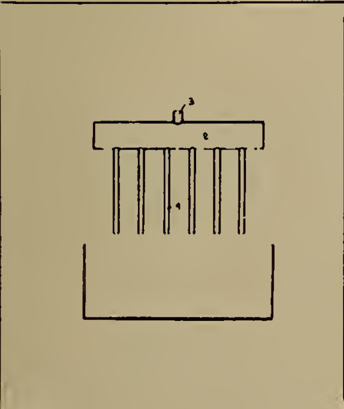


FIG. 1

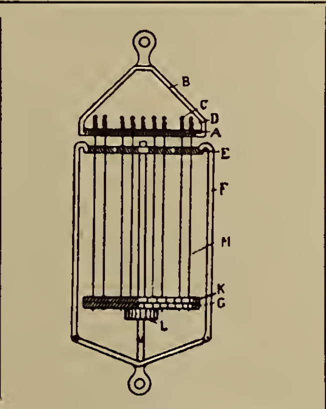


FIG. 3

is formed on the tubes. The apparatus is then drawn out of the bath and moved to one side. Cold water is allowed to enter at 3 and flow out through the open ends of the tubes. A rapid cooling effect is obtained, which causes the tubes to contract. The gelatine coating is loosened and can be removed very readily.

RUBBER FORMS

Another way of making gelatine tubes is to use rubber filaments or rubber tubing closed at one end so that it can be inflated with air. The filaments or threads are stretched on a frame and dipped into the gelatine. After this has congealed, the frame is pulled apart a little and the rubber forms are elongated. The gelatine coating is loosened and may be pulled off without any trouble. When the air-filled rubber tubing is used it is merely necessary to allow the air to escape, when the gelatine can be stripped off at once.

Gelatine tubing of special forms can be made with these rubber filaments. One end of the filament is fastened to the

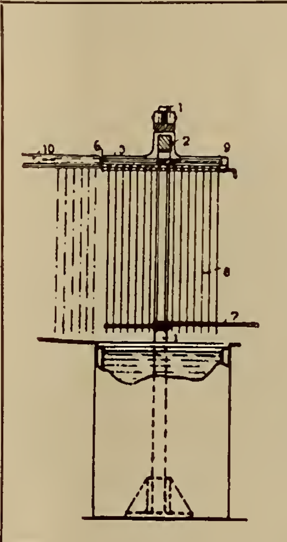


FIG 4

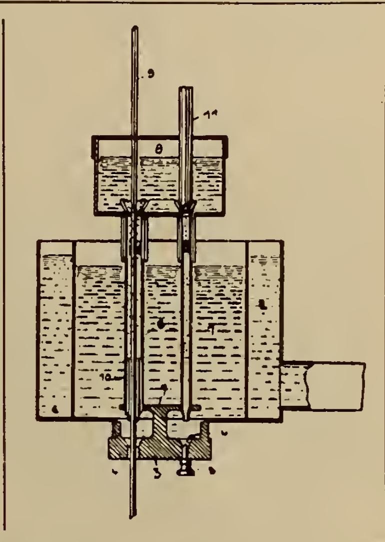


FIG. 5

dipping frame and the other is twisted as many times as desired and then fastened to the other end of the frame. The twisted tubing obtained in this way is used to a large extent for making beads and other articles of jewelry.

TUBES WITH OPEN ENDS

When a cylindrical form is dipped into gelatine, the end of the cylinder is covered with a film of gelatine and a tube with one closed end is obtained. To make tubes with both ends open, the dipping form has a raised portion.

In general a large number of tubes are made at one time. The wires are stretched on a frame or hang suspended from one. Fig. 3 shows an apparatus of the first type, devised by Jirotka. The wires M are fastened to springs D at their upper ends. The tension in the springs keeps the tops upright and tends to pull the wires to the top of the frame. The wires pass through a plate A and are fastened at the lower end between two plates K and G, which can be moved one over the other in opposite directions. A weight L provides the necessary tension in the wires. The plate A is attached to the hanger arrangement B. The finished tubes are stripped off the wires by loosening the tightened plates K and G and pulling down the plate E by means of the hooks F.

Fig. 4 shows a cross-section of an apparatus provided with loose hanging wires. (Bobe.) The post 1 is provided with a holder 2, which can be moved up and down by a suitable lifting arrangement. The holder has guides 3, into which the frame 9 with the wires 8 can be moved in and out. The fastener 6 secures the frame in the guides 3. By means of the movable rod 7, fastened to the post 1, the suspended wires are sub-

*Translated from Kunstoffe, 6, 69-72; 80-81.

[1]Gelatine or glue comes in the trade either broken up in small pieces or ground to a powder of variable fineness. Bone gelatines are often sold in thick sheets or bars. Trans.

merged in the gelatine, contained in the vessel 5. After the wires have been pulled out of the gelatine bath, the catch 6 is loosened and the frame 9 is moved out of the guides 3 on a slide 10 and the gelatine coating allowed to dry.

MANUFACTURE OF LONG TUBES

In the apparatus described heretofore the length of the gelatine tube corresponds to the depth of the gelatine bath, and as the latter cannot be very deep the tubes are comparatively short. The contrivance shown in Fig. 5 is used to make comparatively long tubing. The gelatine bath is surrounded with a hot water jacket. At the bottom of the apparatus there is a mouthpiece, which is pierced with several holes. Each hole has a rod passing through it exactly in the center or when not in use is closed with a stopper. The gelatine runs out through the space between the rod and the sides of the hole and forms a continuous coating around the length of the tube, which extends beyond the opening 4. Every rod is surrounded by a tube 6 which is connected to an oil bath 8. The oil greases the rod so that the gelatine does not stick to it. The length of the rod determines the length of the gelatine tubing.

CONTINUOUS PRESSURE PROCESS

Continuous tubing can be made with the apparatus shown in Fig. 6. The operation of this contrivance requires the use of compressed air. A number of pressure cylinders 2 are set in a hot water bath. The cylinders are filled with liquid gelatine through a valve in the tight fitting cover. At the bottom there is an opening provided with a pin placed in its exact center. The size of this pin determines the thickness of the walls of the gelatine tubing. At the top of the cylinder there is an opening for the introduction of compressed air.

The air forces the gelatine out through the bottom opening. As the material emerges a current of cold air is played upon it and the gelatine tubing is made to congeal. The partly congealed tube falls on an inclined hollow plate 7 through

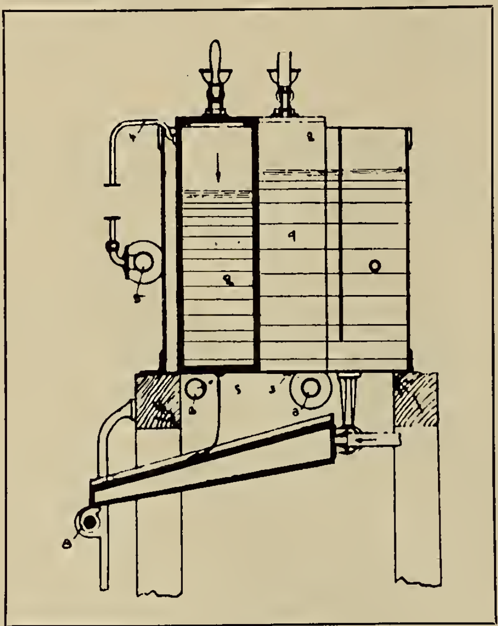


FIG. 6

which cold air is circulated so that the gelatine is cooled still further. The plate is given an oscillatory motion by means of the cam 8. A continuous tube of any desirable length is obtained in this way.

GELATINE CAPSULES

The dipping process is used to make capsules. Short pegs are fastened to a plate and the contrivance is dipped into a gelatine bath. The familiar capsules are formed in this manner. They are removed from the pegs and cut to the proper length. As one open end capsule must be placed within another, different sizes of each are required. These are obtained by making some pegs larger than others.

In another contrivance the pegs are arranged in a continuous band which runs over a pulley. The band dips into the gelatine bath and then runs along a sloping path. In this way capsules of very uniform wall thickness are obtained. After that the bands wind around a drum which rotates until the gelatine has congealed entirely. To cut off the capsule a

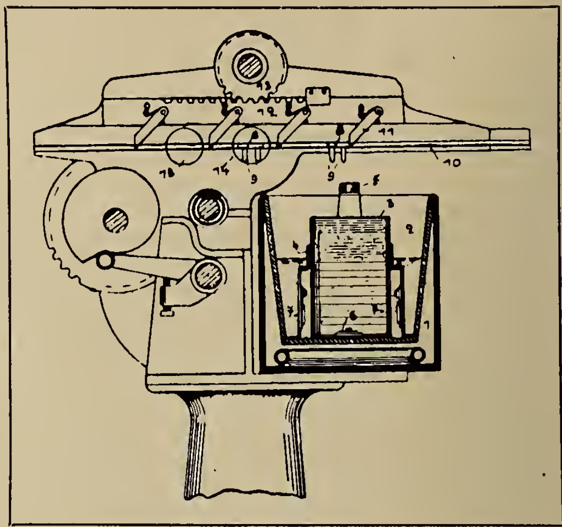


FIG. 7

band knife is used in which there are perforations with sharp edges. The capsules fit into these perforations and are cut off by the sharp edges. The band then travels along to another contrivance which strips off the waste gelatine remaining on the pegs; it then passes over brushes which coat the pegs with a little oil and finally is submerged in the gelatine bath again. The capsules fall into a part of the apparatus which pushes one-half capsule into another and the finished capsule drops into a collecting basket.

AUTOMATIC CAPSULE MACHINE

Capsules are made in large quantities in automatic capsule machines which are very ingenious in construction. Fig. 7 shows one of these machines, invented by B. W. Scott. There are two distinct parts to this machine: one, the gelatine container and lifting apparatus (the lower part of the figure); and two, the pegs and the contrivance for moving them across the gelatine bath. The first part consists of the usual water jacket in which there is placed a cylinder filled to the brim with melted gelatine. This cylinder 3 is set in a tight fitting housing 4. Both the cylinder and the housing are provided with valves at 6 and 7, both opening inward. A suitable contrivance raises the cylinder at the proper time, when the melted gelatine flows into the housing through 7, and when the cylinder is lowered again the gelatine runs into it through 6 and overflows. This prevents the formation of a skin of gelatine at the brim of the cylinder.

The second part of the apparatus consists of an endless band of pegs, traveling in guides from left to right (see Fig. 7). The motion of the band is controlled by a rack and pinion contrivance to which latches 11 are fastened which push the pegs along. The motion is intermittent, allowing time for dipping the peg in the gelatine cylinder 3 which is raised at the proper time to meet the peg which has stopped moving just above it. After the peg has been dipped, the cylinder is lowered and the peg travels along to the drying part of the apparatus. The entire action of the dipping machine is automatic.

Fig. 8 shows the arrangement of the complete apparatus. A is the dipping machine, B is the drying contrivance. The pegs pass through B and finally reach C from which they are fed to the assembling machine D. The feed is so arranged

that all the longer pegs are made to pass to the under part of D, and the shorter pegs to the upper part so that one-half of the capsule can be inserted into the other very simply. A suitable cutting tool cuts through the gelatine, which is then pulled off the pegs. The finished capsule is collected in baskets. The waste gelatine is removed from the pegs and after

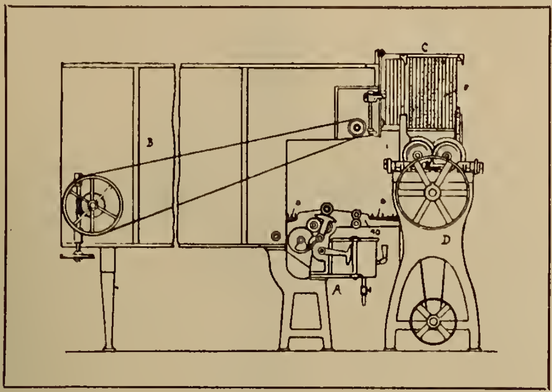


FIG. 8

the latter have been greased slightly they are pushed into the guides 10 and proceed to the dipping machine for a repetition of the operation.

The apparatus shown in Fig. 9 represents an entirely different method of manufacturing capsules. There are two gelatine baths, one at the top and the other at the bottom of the apparatus. These baths are connected by means of compound tubes, that is, two concentric tubes, provided with two stopcocks. While the top valve is open, the bottom valve is closed and the gelatine runs down in the space between the two tubes. A coating of gelatine is formed on them and the rest of the gelatine runs out when the bottom valve is opened, thereby closing the top valve automatically. After congealation takes place the gelatine tube is removed and put through a machine which cuts it up into proper lengths and closes the ends in one operation.

BALLS, ARTIFICIAL FRUITS AND OTHER LIKE HOLLOW OBJECTS

The dipping process is used to make these articles. As many of the latter must have small openings only, the dipping forms are made of rubber so that they can be inflated with air. The forms have an inner supporting frame, so that they do not collapse when immersed in the gelatine bath. They are placed in specially made holders, and provided with valves

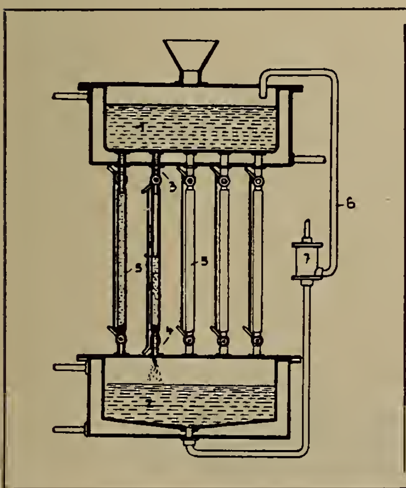


FIG. 9

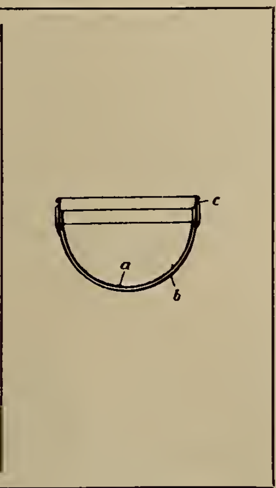


FIG. 10

so that the air can be released and the forms deflated after congelation. The forms can then be drawn out of the gelatine product through the small opening left at the top where the neck of the rubber form extended.

Metal forms are used to make hemispheres and the like. To avoid greasing the form, an ingenious device is used, as shown in Fig. 10. This consists of a ring c which fits into the forms and is dipped into the gelatine bath along with it. The gelatine coating b does not stick to the mold and can be removed very easily by stripping off the ring c.

CLOSED HOLLOW SPHERES

Fig. 11 is a diagram of a machine used to make completely closed hollow spheres. There are two drums, whose axes are parallel to each other and over which an endless band winds. To this band the dipping forms are fastened in such a manner that they can be rotated. This is done by a cog wheel arrangement as the band passes around the helical shaped grooves in the drums. Under drum 1 at a distance equal to the pitch of the helical windings there is a container 5 in which there are some oil impregnated bulbs and a gelatine bath. The forms dip into the former first and then into the gelatine. They then continue on their way around the drum and finally reach drum 2 which is surrounded by a drying chamber where the gelatine congeals. The forms return again to the first drum. At this point the claws of a seizing contrivance grip the form and strip off the gelatine body and let it fall into a pair of clamps which are arranged at certain intervals on an endless chain 7. The clamps close so that the

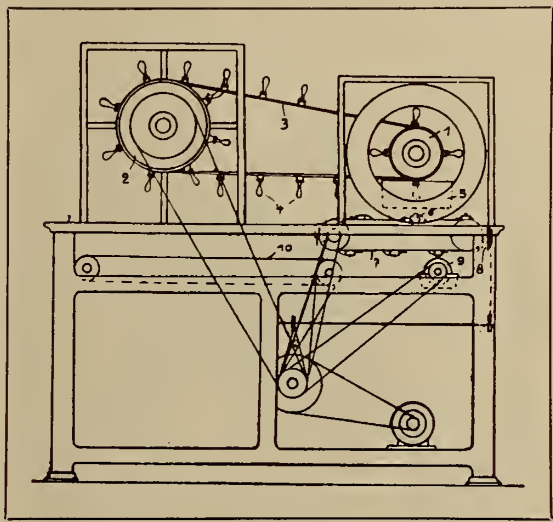


FIG. 11

neck of the globular gelatine body extends beyond them. The clamps then move along to a knife 8 which cuts off the neck of gelatine, so that a sphere is obtained with a hole in the top. This hole is closed up by dipping the sphere (still held in the clamps and moving along automatically) in a concentrated gelatine bath. The clamps open and allow the spheres to fall on a belt conveyor 10 which takes them to a moderately heated drying chamber. The heat causes the air within the spheres to expand and in this way the sphere attains a comparatively regular shape.

BEADS AND PEARLS

The shape of gelatine beads varies considerably. Sometimes the beads are more or less regular spheres or like bodies, which are pierced with holes for the most part. Then again they may be different lengths of cylindrical or many-sided tubes. For this reason the methods of manufacture are very varied.

Spherical beads are made by the aid of the apparatus illustrated in Fig. 12. The gelatine is squeezed out of the press 1 through a cylindrical tube provided with a center pin 3 and then passes between two rollers. These rollers rotating in the indicated direction (see figure) have hemispherical depressions in their circumference which form a string of spherical beads out of the tube of gelatine. The beads are connected by small pieces of tubing.

In another process the beads are made either by hand or by machines from gelatine which has been rendered plastic by

the addition of a small amount of water. The beads are then dipped for several seconds in hot water at 60 to 70 deg. Cent. and then cooled off by a current of air or by dipping in cold water. In this way they are made very smooth. To fasten together such beads, heated pieces of metal are stuck into them. Large beads are not made from pure gelatine. Very often the center is formed of cotton or glass wool wadding and a gelatine coating is congealed thereon. The finished beads can be given a mother-of-pearl gloss in the usual manner and then can be japanned or made insoluble by treatment with formalin.

THE STAMPING PROCESS FOR MAKING BEADS

Beads can be stamped out of the gelatine sheet. By this process, at first the string holes are stamped out and then the entire bead. The gelatine is rendered flexible by the addition of glycerine, so that the stamping can be accomplished without any trouble. In order to give the pearls the desirable gloss, they are coated with a varnish lacquer or with a solution of collodion. At the same time they are made very resistant to the action of moisture.

A very original process for manufacturing beads, gems and ornaments has been devised by H. Poussole. The different articles are first stamped out of the gelatine sheet in the rough. Then these rough forms are placed on a metallic screen and heated very carefully with a gas burner. After a short time, the gelatine begins to swell and as the heating is continued, the rough edges of the stamped form fuse

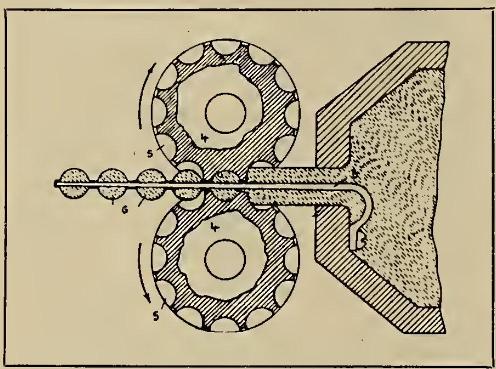


FIG. 12

together and become smooth, so that an object is obtained that is larger than the original but entirely smooth all around. When the object is cooled off, it shrinks, but still retains its shape, which corresponds exactly to the original rough stamped form.

Large quantities of beads are made from gelatine tubing, which is itself manufactured by any one of the processes described above. The tubes are cut into any desired lengths and then shaped into the bead. The interior of the tubing is filled with an easily workable doughy substance, such as flour dough, which is used for making noodles. This then becomes the center of the beads, effects a saving in gelatine and makes the beads more resistant to wear and tear.

FACETTED BEADS

Besides the type of bead described above the bead with a many-sided cross-section, the so-called facetted bead, is very popular. When the stamping process of manufacture is used, the facets of the bead are not very lustrous and must be made so by the application of a lacquer. This is merely a makeshift arrangement as the lacquer loses its gloss comparatively quickly.

A process has been invented by K. Wirth which avoids this disadvantage. Cylindrical beads are stamped out of gelatine sheets and are stuck on pins into which they fit very tightly. The outer surfaces of the beads are moistened slightly and they are placed in a bipartite die. The die is cut into the desired profile and possesses highly polished surfaces. After sufficient heating to make the beads plastic they are compressed in the dies for one to six minutes. They are then dried and strung. To prevent the beads from sticking together during the operation of pressing, the gelatine sheets, from which they are stamped, are made insoluble on the upper

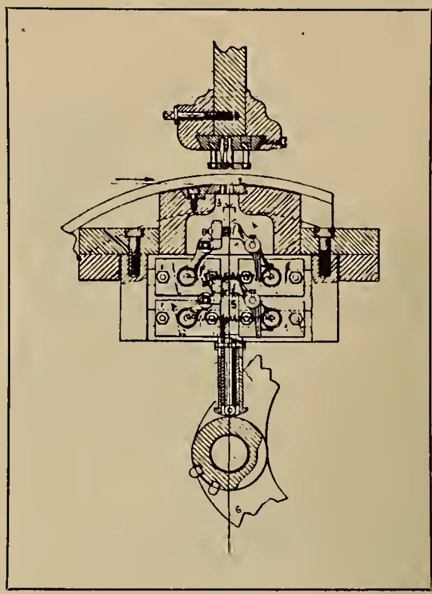


FIG. 13

and lower surfaces by painting with formaldehyde. When a composition gelatine is used, this procedure is unnecessary. In place of press molds, rollers made from metal glass or porcelain can be utilized to good advantage. These rollers are cut out into the desired outlines and the bead is pressed between two rollers after having been made plastic by heating.

Beads or pearls are made from gelatine tubes and worked up in various forms and profiles. The tubes can be placed in lathes and rotated about their longitudinal axes, whereby the facets and other similar profiles may be cut out of the gelatine, drawn out or burnt out by corrosion. The gelatine scraps are recovered and reused.

GELATINE TINSEL

Gelatine tinsel is much less expensive than the metallic tinsel. The round disks with small perforations are stamped out of gelatine slabs and are strung on threads. Two dies and matrices are used, the finished product being made in two steps. The matrix in the second step has a sharp pin which pierces the disks.

An automatic apparatus for cutting the hole in the disks and stringing them on a thread is shown in Fig. 13. The machine operates in a manner very similar to that of sewing by hand. The contrivance in the upper part of the figure holds the pins at the outset. The pins pierce the gelatine disks and are drawn through underneath by a pair of clamps and then returned to the clamps that held them in the first place. The

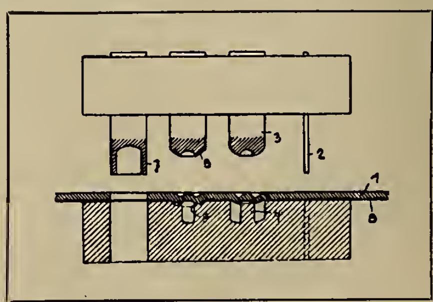


FIG. 14

perforated disks are finally pushed through the pin, attached to the cord 6 (see figure) and strung.

Another type of tinsel, which is used in large quantities, is made in the shape of a dish or bowl. Fig. 14 illustrates a ma-

chine used for making this kind of tinsel. The gelatine sheet is moved from one stamping die to another until it has been shaped to the desired form. The operation is very simple, merely moistening the gelatine to render it plastic and stamping with various dies as many times as necessary. Very many different shapes and sizes of tinsel can be made in this way. Buttons, stones (gems) and other like articles can be stamped out of thick sheets of gelatine by the same process.

GELATINE COMPOSITIONS

Most of the articles, made according to the various methods described above, are formed out of the pure gelatine, except for the small quantity of dyes added to give a distinctive color to the product. This is particularly true of gelatine tubes. However, considerable quantities of this commodity and others of similar nature have been manufactured from gelatine compositions. An example of such a composition (Traube and Michaelis) is as follows: 150 grams glue, 40 to 100 ccm. of glycerine and about 100 grams powdered talc. Sheets or slabs are cast from this mixture and rendered sticky on one side by heating and then wound around a metallic drum. When the longitudinal seam is sealed by melting the gelatine around it, the hardening of the finished pipe is accomplished in the usual way by the use of formaldehyde. This process is very similar to that of manufacturing rubber tubing

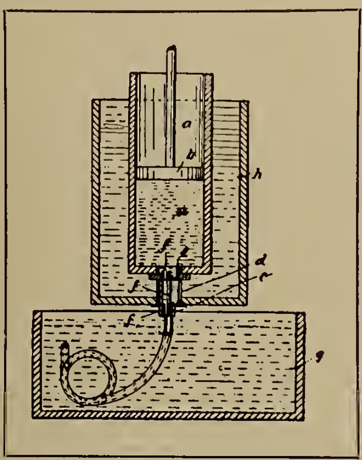


FIG. 15

and piping. Just as in that process, different fabrics can be inserted between the layers of gelatine composition or else the mixture can be cast around the sheet of fabric.

Another gelatine composition, consisting of talc, asbestos, chalk and other like substances, is worked up in an incorporating rolling mill just as is used to compound rubber. The mass is then drawn out on a calender to form sheets and covered with a layer of fabric. Several layers may be built up in that way and then the product is wound around a drum to form a tube or pipe. This is wrapped in moistened paper and heated for a certain length of time. The paper tends to contract as its moisture is evaporated, so that a certain pressure is exerted on the tubing, which results in a more compact adhesion of the several layers that go to make up the pipe.

Instead of making the piping by winding sheets around drums, a press is used as illustrated in Fig. 15. The cylinder *a* contains the gelatine and is surrounded by a hot-water jacket *h*, so that the gelatine can always be kept at a temperature of 450 deg. Cent. The gelatine is squeezed through a die, fastened to the lower end of cylinder *a* by pressure exerted through the piston *b*. The die is made in such a way that a tube is formed with a hollow center. This is done by making the pin, which is inserted in the opening in the die, hollow. Directly underneath the die there is a container filled with alcohol or any other suitable liquid which can be kept at about 15 deg. Cent. The continuous tubing, squeezed through the die, falls into this cooling bath and is congealed immediately. Its hollow interior permits the penetration of the congealing fluid and makes the action just that much more effective and rapid.

Many other objects can be obtained from gelatine compositions by squeezing them through dies and quickly cooling the product as it is formed. Hollow articles are made in parts and then joined together by melting. To harden the inner surface of such objects, as for example in making balls by combining two hemispheres, a small piece of absorbent cotton, moistened with a little formalin, is fastened on the inside of the hemisphere at a point where the gelatine wall has been thickened. After the exterior of the ball has been hardened, the ball is inflated by means of a sprayer which pierces the thickened wall of the ball. Afterward, the hole is closed up with a gelatine plug. The hardening solution consists of a 3 to 5 per cent solution of formalin to which a little glycerine is added, in a proportion corresponding to the glycerine content of the gelatine composition.

THE MACKENZIE OIL FIELD

By T. O. BOSWORTH

THE two main alternative routes from Edmonton to Fort Norman are the Athabasca River route of 1370 miles and the Peace River route of 1695 miles. The two routes coincide for the final 868 miles, which includes the steamer route across the north end of Great Slave Lake and down the Mackenzie River. On both the Athabasca and the Peace the ice goes at the end of April; on the Mackenzie it breaks up in the latter part of May; but the ice on Great Slave Lake delays transportation, as it generally remains until the middle of June. The Mackenzie River remains open for navigation for about four and a half months.

At low water, the channels of these rivers are not to be depended on for boats of more than six feet draft. The current ranges from four to two miles an hour, going from south to north. The lakes are subject to bad storms, and it is sometimes rough on the Mackenzie River, which is from one to three miles wide.

The winter temperatures in the north do not go much lower than in the worst part of winter at Edmonton or Winnipeg—but they continue much longer. "Forty below" weather may last for six weeks or more.

Until the oil field is further proved and developed, the oil will be brought southward along the waterway, to the railroads of Alberta, by the route described. Motor barges of several hundred tons' capacity can be employed. Two fleets of these will be required, one operating north of the Smith portage, and the other south of it. The journey for the oil consists of three parts:

1. *Oilfield to Fort Smith.*—From the wells, the oil will be conveyed up the Mackenzie River, across the end of Great Slave Lake, and then up the Slave River as far as Fort Smith. This voyage of about 800 miles will be performed by the first fleet of barges.

2. *Fort Smith to Fort Fitzgerald.*—At Fort Smith, where navigation is interrupted by the Smith Rapids, the oil will be pumped across the rapids, through an 18-mile pipeline, into the second fleet of barges at Fort Fitzgerald.

3. *Fort Fitzgerald to Fort McMurray.*—From Fort Fitzgerald the oil will be conveyed along the upper portion of the Slave River, across the end of Lake Athabasca and up the Athabasca River as far as Fort McMurray, where tank cars on the railroad will receive it.

Further railroad construction, and improvement of the waterways, also, are certain to be undertaken if the developments in the oil field justify them. Possibly the oil will be partly refined in the north, to reduce the cost of transportation. If present hopes and expectations are realized, the oil will doubtless eventually go by pipeline to one of the inlets on the Pacific coast. The shortest distance to tidewater is 550 miles.

The strata exposed in the Mackenzie oil-field district include:
Tertiary—Shales, sandstones, and lignite.

Cretaceous—Clay-shales and sandstone.
Devonian—Limestones, shales, and sandstones.
Silurian—Limestones, etc.

It is in the Devonian only that the oil and gas have been found.

OCCURRENCE OF THE PETROLEUM

The remarkable character of the Fort Creek shales and Beavertail limestone, rather than the oil seepages, led to a favorable view of the prospects of this field. These rocks are black with bituminous material, which appears to be present as a fixed constituent. In some places, where these beds are much exposed, the bituminous odor is so strong that it may be noticed at a distance of half a mile. Fluid oil is not visible in these bituminous rocks, though where they pass under water some liberation of gas is seen. But oil might reasonably be expected in the porous beds of the overlying thick series of clay-shales and sandstones, and also there was a good chance that at depth, and under favorable structure, accumulations of petroleum might occur within the black shales and limestones themselves.

An examination of the overlying Camp Creek series in several localities showed either oil seepages or the presence of oil when the rock was crushed under water. The principal seepages were seen on the shores of the Long Reach, where the river flows for 75 miles along the outcrop of the Camp Creek series.

Extending over many thousands of square miles there is 1000 feet or more of richly bituminous beds, and overlying these rocks is 2000 feet of shales and sandstones, from which seepages of oil arise. This mass of petroliferous deposits is traversed by large anticlinal folds.

The high parts of the anticlinal hills are not now favorable territory, for there the oil-bearing beds have been denuded away, but on the flanks of the folds, and on certain low parts of the crests, and on the minor structures, the petroliferous beds are more or less intact.

The oil has a paraffin base and is of high quality. The seepage oil, obtained on digging in the outcrop of the Camp Creek beds, has a greenish-black color, and a strong paraffin smell. The specific gravity is 0.905. The crude oil from the well is of light color, low specific gravity, high gasoline content, and low cold test. From an analysis made at Alberta University, in commercial terms the oil consists of gasoline 22.5 per cent, illuminating oil 38.5 per cent, light lubricants 33.9 per cent, and medium lubricants 4.1 per cent, with a refining loss of 1 per cent.

The petroleum within the region here discussed appears to have been first recorded about a century ago by Sir John Franklin, who saw, near Bear Mountain, "sulfurous springs and streams of mineral pitch."

Also, for the past fifty years or more, a "tar spring" far inland from the river has been known to the Hudson Bay Co.'s men at Fort Good Hope, who have utilized its seepage oil for tarring their canoes.

In 1887, an exploration of the Mackenzie Basin was made by R. G. McConnell, who reported the occurrence of bituminous or petroliferous rocks throughout the valley.

It was not until 1919 that a drilling outfit was conveyed into the Northwest Territory, by the Imperial Oil Co. The location of this first test well was chosen in 1914, as a site where a hole of moderate depth could not fail to penetrate the several petroliferous formations which had been found.

The well is on the river bank about half-way down the Long Reach, near the mouth of Camp Creek, where there are copious seepages of oil. Geologically speaking, the location is upon the outcrop of the lower measures of the Camp Creek Series, low down on the southwest flank of the Wolverine anticline, about 8 miles from the axis of the fold.

It was clear that the oil rocks would lie rather shallow here, but by not going farther "down the dip" there was less risk of finding the beds occupied by water and less chance of failure to reach the desired horizons because of engineering difficulties in such a remote country.

The well was drilled during the summer of 1920. Almost from the start oil came into the hole, and before a depth of 100 feet was reached a yield of five or ten barrels a day could be obtained.

After passing from the Camp Creek series into the dark Fort Creek shales, the oil showings still continued, until, at a depth of 783 feet, a strong flow of oil was encountered which spouted to a height of 70 feet. After about ten minutes the well was capped. Some hundreds of barrels of oil issued from the well before it was finally shut in, but no dependable estimate of its capacity can yet be made. It is thought that the initial output will be at least 500 barrels a day.

Whether or not this first well will be a steady, large producer remains to be seen, and, in any case, many more wells must be drilled before the importance of the field is fully proved.—Extracts from Paper Read at Meeting of Royal Society of Arts, April 27, 1921.

DEVELOPMENT OF THE HUMAN FOOT

In new-born infants the soles of the feet are turned opposite each other exactly as they are in climbing animals and the great toe likewise undergoes conditions of development which indicate that it was derived from the "thumb" of a climbing foot. Even at the present time there are races of men which are distinguished by the great flexibility of the foot. A German observer, named E. Bälz, remarks, that the thumb-like use of the great toe is very remarkable among the Japanese. This toe can be moved independently of the others and can be pressed so firmly against the second toe that quite small objects can be picked up by it. A sewing woman often picks up the goods she is working with between her toes and "handles" it in this manner with great ease. Another observer describes similar use of the toes among manual laborers—or should we say pedal laborers—in some parts of India. The Australian blacks, whose feet are marked by the shortness of the great toe and the comparative length of the other toes, are capable of holding a wooden stick from which they are making a spear with the foot, clasping it quite as firmly as one of us could do with his hand. This remarkable grip possessed by their toes is also very useful to them in tree climbing.

It is not certainly known how this power of opposition of the great toe to the other toes, and the great flexibility of the foot has been lost. A recent writer, however, Herman Klaatsch, in his work *Werdegang der Menschheit usw.* (The Development of Humanity, etc.), expresses the opinion that this loss is due to a peculiar sort of tree-climbing which is still common among savage peoples. The Australians, for example, climb smooth tree trunks without making notches in them. A flexible twig is bent around the stem and held by the climber with both hands and pushed steadily higher up the trunk as the man ascends. It is quite possible that this sort of climbing machine may have been very extensively used among the ancestors of man. It must be remembered that the tops of trees were a very happy hunting ground for them, so to speak, with respect to birds and their nest, as well as other small animals, besides which they served as a refuge in times of danger and possibly, too, as shelters by night. Individuals who happened to have feet varying in the direction of the present human foot, from the norm of the climbing foot, would possess an advantage in such cases, while in ordinary individuals the divergent great toe would act as a hindrance.

It is worth noting, too, that the marked development of certain groups of muscles in human beings, which are quite insignificant—namely, the masses of muscles found upon the shoulder and upon the buttocks, are precisely those which are especially serviceable in *human* mode of climbing, for the thrusting upwards or the pushing downwards respectively of the trunk. Moreover, it is these same muscles which are best suited for the molding of the spine in an upright position, as well as for that refraction of the shoulders by means of which a free movement of the head is secured.

Why Flowers Fade*

The Processes of Withering, As Reduced to Botanical Terms

By Hans Fitting, University of Bonn

An address presented before the Natural History Society of Rhenish and Westphalian Prussia, on the occasion of their 75th principal assembly, Oct. 9, 1920.

I. THE PROCESSES INVOLVED IN WITHERING

In the case of most living organisms the death of the individual or some of its parts is as characteristic as its development . . . and deserves as careful an investigation. . . . Such a group of processes with respect to the blossoms of plants forms the subject of the following paper. And we select this subject, not only because of the general interest which the fading of flowers and the phenomena of the post-florescence possesses for flower lovers and for gardeners, as well as for florists and for plant physiologists, but also because the investigations which have been conducted along this line during the last ten years, have given us a far more profound understanding of these processes themselves and have likewise thrown important light apparently upon the general physiology of plant development.

Even a superficial observation of flowers reveals that their withering is not of a single type, but that as is the case in so many phenomena of organic life different ways and means are involved, even in those nearly related to each other. The various portions of the flower, the calyx, the corolla, the stamens, and the ovary, are merely modified forms of the leaves and share the properties of these, including the process of withering. The leaves of plants wither in different ways. In the case of herbs the leaf and stem die down together through a process of drying or rotting, but in the case of most trees and shrubs the leaves are discarded while still living through an active vital process. . . . This consists in the formation of a transverse layer of cells formed at the base of the leaf stem in such a way as to neatly cut the leaf off. . . . A process of "autotomy" such as is accomplished by means of a different mechanism in the animal kingdom. Only in exceptional cases, as in the oak and the beech, are the leaves not discarded while still living but remain in a dried condition clinging to the tree until the buds begin to unfold in the following spring. This thrusting off of the leaves is generally preceded by a very striking change of color, except in some cases such as that of the alder. This is due partly to the decomposition of the grains of chlorophyll and partly to a formation of certain pigments especially yellow pigments, which consist partly of carotin and xanthophyll, which are insoluble in water, partly in chemical combinations not yet understood, which are soluble in water; very frequently also red anthocyanins to which the red color of leaves is due. These changes of color are in their turn due to a diminution in the protoplasm of the leaf cells and connected with this is an emigration of valuable leaf materials into the stem, especially of nitrogenous albuminoids, and phosphorus-proteids as well as a portion of the potassium, while other substances such as the materials of the cell wall together with calcium, magnesia, and other material constituents remain behind.

The methods by which plants get rid of those parts of their blossoms which have already fulfilled their function, are very similar on the whole but vary from each other in certain particulars.

THE DROPPING OF PETALS

1. Portions of the flowers are divided off by a transverse layer of cells of different character as described in the case of ordinary foliage. However, while these separation seams as we may call them consist of very small round cells rich in plasma, they are not (as is usually the case in the foliage), formed shortly before this self-amputation, but exist from the beginning. The process of amputation itself may require only a few minutes or even seconds, and while the portions of the flower which are discarded appear to be perfectly fresh and unchanged. This is true in the case of the flower petals of poppies, many of the rose family (including not only roses themselves but peaches, apples, plums, almonds, apricots, pears, and quinces), varieties of geranium, erodium, and pelargonium, as well as in many of the ranunculæ, the magnolias, the flaxes, the myrtles, of the umbellate plants, of the azaleas, the scrophularias, the veronica, the digitalis, the borage, the fuchsia, etc., etc.

In other cases the discarded portions wither before their amputation, a process which begins more or less near the point and which is accompanied by a greater or less change of color, as in the tulips, the lilies, the fritillaria, the iris *ensata*, most of the cruciferæ, the snapdragon, and many of the Laliatæ, the pumpkin, the evening flowers, etc.

2. In some other plants the parts of the flowers with which the plant is done are not amputated while still living but undergo a change of color and then remain withered and dry, clinging to the fruit for a longer or shorter space of time; in such cases it is probably true that in some plants these portions of the plants assume new functions, such for instance as facilitating the distribution of the ripened fruit. Blossoms of this type include the lily-of-the-valley, the narcissus, the orchids, most of the irises, the clovers, the erica, many of the pinks, the tobacco, the petunias, the asters, and probably the violet and pansy. . . .

Many differences of detail appear in the withering process according to the part of the blossom discarded, the order observed, etc. Frequently the entire blossom is cast away, sometimes while quite alive and fresh as is the case with the male blossoms of many plants; sometimes the blossom withers before being dropped as in the case of the male flowers of the gourd and pumpkin family; sometimes the upper portion of the blossom separates while quite fresh from the ovary beneath it, as in the fuchsia; sometimes this part is entirely withered as in the primroses, etc., sometimes the calyx drops off before the petals as in the case of the poppy, and sometimes at the same time as in the ranunculæ, the cruciferæ, the touch-me-not. In other cases still the plant amputates only the petals while the parts of the calyx remain clinging to the fruit either dry or withered, sometimes the stamens also remain in a withered condition as in strawberries, pears, roses, flax, etc.; or it may be that the calyx is retained while the stamens are amputated either before, after, or at the same time as the petals. Sometimes, too, the style is dropped while still living after fertilization has taken place, while sometimes, on the other hand, it clings to the ovary in a dried condition.

In all those cases where the portions of the blossom discarded are still living, the alterations which occur in them are of peculiar interest. . . . There are certain definite cases of partial death. . . . These processes of senescence and death consist first in the above-mentioned change of color—*i.e.*, in a yellowing or fading or in an actual change of color, *e.g.*, very frequently from blue or violet to red which indicates the appearance of acids in the cell sack and sometimes, on the contrary, in the change of red to blue or violet tones which indicate a removal of acids from the cell sack. In the aging blossoms of the pulmonaria, for example, this change of color from the red of youth to the blue of age is very striking. It is a definite sign of irreversible chemical processes. (In some flowers a similar change of color is not due to age.

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but to an external factor like heat, as in varieties of the erodium; even a few degrees rise in temperature changes the color of these blue blossoms, first to a wine red and then to a clear rose color, and this is true both of the dead and the living petals. When the flower is cooled off again the blue color gradually returns.) The next step in the progress toward death consists in a gradual withering and crumpling, often accompanied by the passage of the cell sap from out of the cell into the intercellular spaces. . . . This exudation of the sap indicates that the impenetrability of the cell plasma has diminished or ceased as is customary sooner or later in the death of living cells. . . . Possibly, too, the withering and crumpling referred to are directly due to this exudation of the cell sap.


Fig. 1.


Fig. 2.

1: Front view of Phalaenopsis, the day after opening. 2: Same flower viewed from the side before pollination

It must not be supposed, however, that the increasing growth of the fruit causes the death of other parts of the blossom through a suction of the cell sap as might be thought; for, as a matter of fact, the morbid processes follow the same course in unfertilized as well as in fertilized flowers. However, it seems to me not improbable that, at least in those cases when the senescent portions remain clinging to the plant for a considerable time, material may emigrate from them before they are actually dead. This is indicated, at any rate, by my personal observation that in the case of the tropic orchid *Rhynchostylis retusa* the plasma is impoverished both before and during the process of withering.

The Closing of the Flower.—In the case of many flowers the process of fading is complicated by the fact that the blossoms first close to a greater or less degree before they actually


Fig. 3.


Fig. 4.


Fig. 5.

Further phases of Phalaenopsis. 3: Front, after it has begun to close. 4: Side, 24 hours after pollination. 5: Side, 48 hours after pollination

wither. This is the case in the irises, in many though not all orchids (Figs. 1-5, 6-9) the mallows, most of the cruciferæ, the primrose, many cactuses, etc. These closing or rolling up movements are definite life processes, which, under certain conditions, take place in a very brief space of time, only a few hours. In many cases they are based upon the fact . . . that the growth upon the convex side is more rapid than that of the concave side. In other cases it appears, according to measurements made by me of the tropical orchid *Phalaenopsis amabilis* (Figs. 1-5) the closing movement is effected by a shortening of the concave side. This may be followed by an excision of the part of the blossom concerned or by its withering or by both.

Even more remarkable are further complications in the fading process which depend upon whether the blossom was fertilized or unfertilized. In the latter case, the fate of the separate parts of the blossom may be very different; *e.g.*, this is peculiarly striking in certain tropical orchids, such as the *Phalaenopsis violacea* which has marvelously beautiful blossoms of a mingled white and violet: if the latter are not fertilized they close themselves (Figs. 6-8), grow yellow, wither and fall after a few days. If, however, they are fertilized, they likewise close themselves and begin to grow yellow and wither; but after this they gradually acquire an intensely green color, become once more firm in contour, begin to grow and retain a living and green condition until the fruit is ripe (Fig. 9). . . . Similar differences are found in the style of many tropical orchids; if not fertilized they become yellow and withered, but when fertilized while they begin by turning yellow, they immediately, thereafter, or at the same time, swell greatly (Figs. 10-11) and remain clinging for a long time to the ripening ovary. . . . Still other alterations including those of an anatomical nature, may be experienced by the corolla or the calyx as a result exclusively of fertilization, which we cannot here pursue, however, in spite of their importance with respect to physiological developments.

II. THE CONDITIONS THAT CONTROL THE PROCESS OF WITHERING

Let us now inquire into the causes of these changes. We observe, to begin with, that every variety has an absolute dura-


Fig. 6.


Fig. 7.


Fig. 8.


Fig. 9.

PHALAENOPSIS VIOLACEA

6: Front, day after blossoming. 7: Side, day before pollination. 8: Side, three days after pollination. 9: The ripening fruit, with a perianth entirely green

tion of the blossom which is peculiar to itself, just as the duration of the foliage is specific in nature; while in our latitude the latter has among deciduous plants only *one* period of vegetation, lasting therefore only a few months. This period may continue for several years among the so-called evergreen plants. In the same way the persistence of flowers is very various. Some kinds of plants, to the sorrow of flower lovers, retain their magnificent blossom for only a few hours; there are others which retain their beauty for several days; while there are yet others finally, *e.g.*, the tropical orchids which remain fresh and lovely for two or three months.

I quote from Kerner the following list, which, however, needs still further testing:

"The flowers of the *Hibiscus prionum* persist only three hours, the night blooming cereus (*C. grandiflorus*), seven hours . . . the *Geranium pratense*, two days; the *Digitalis purpurea*, six days; the *White lily*, six days; the *Striped Pelogonium*, seven days; the *European cyclamen*, ten days; the tropical

orchid, *Caltleya labiata*, thirty days; the *Phalaenopsis grandiflora*, 50 days; and the *Odonloblossum rossii*, as much as 80 days." Thus we see that the duration of the blossom varies greatly even in plants which are closely related to each other.

Thus, while there are many orchids, whose blossoms persist uncommonly long, there are others which remain fresh only a few minutes, or perish at most within a day.

The Effect of Fertilization.—In many cases this varying persistence of the blossom seems to depend upon the chances of fertilization under the conditions in which the plant grows—when these are abundant the plant does not "need" to persist very long; when they are few as among the orchids the long continued persistence of the blossom is favorable to fertilization. However, this rule must not be regarded as of universal application. . . . In some cases the withering at the end of a definite time is based upon unknown *internal* conditions: it is probable that the conditions which control senescence are inherent in certain plants, while in others we may assume that the post-florescence is controlled by a correlation of processes with those taking place in the other parts of the plant—though as yet we do not know what these processes are.

Flowers as Room Decoration.—The knowledge of the conditions that govern the fading of flowers is of much importance when the latter are used to decorate our dwellings. Naturally, those which persist at least a few days are preferable to those which are more ephemeral. . . . It must be remembered, however, like all other vital phenomena, that the fading of flowers is strongly influenced by external factors, especially by heat or cold. . . .

Much more remarkable is the fact that many flowers are capable of fading *prematurely*, *i.e.*, long before the given persistence for a given temperature has been reached. In such cases external factors are responsible. . . .; the most important of these is the pollenization and fertilization of the blossoms.

Thus, for example, the large white blossoms of the orchid *P. amabilis* whose unfertilized flowers remain in blossom for several weeks even in the hot climate of Java, begin to close 12 hours after being fertilized. . . those of other tropical orchids within a few days; the corolla of the borage fall from 2 to 7 hours after fertilization . . . and those of the erodium within an hour. . . .

Let us inquire into the nature of the influence thus exerted. Certain experiments made by me from 1909 to 1911 give a definite answer to this question—they show that the persistence of the blossom may be strikingly abbreviated by entirely different external influences. Thus the flowers of a number of those tropical orchids, which are caused to wither prematurely by fertilization and *only* those (no others and no later) perish when the stigma is wounded even slightly by piercing or cutting or by the brushing off of its papillæ. In the same manner the petals of the *erodium manescavi* drop off in from 40 to 80 minutes if the stylus be squeezed by a pair of pincers. . . . In all these cases injuries to the other parts of the blossom, even of the petals themselves, are entirely without effect. Such wounds, naturally, which are made at a distance from the perishable parts of the blossom, can, naturally operate only through some sort of influence exerted by the local wound, *i.e.*, of the stigma or the style . . . . Such an influence whether of chemical or other nature must be regarded as we shall see, as being a form of irritation. . . .

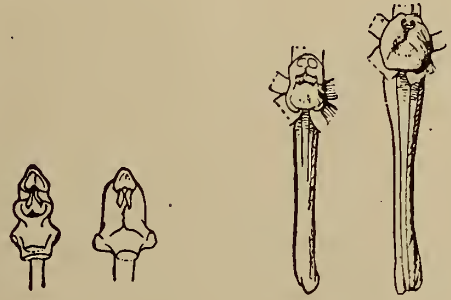
For example, the stigma or rather the upper part of the style appears to be the most favorable *organ of perception* for the irritation produced by the wound in the case of the orchids cited above. . . .

Other influences operate to cause premature fading much more rapidly however, than the wounding of the stigma or the style. . . . Thus I have been able to demonstrate that a sudden heating of the corolla of the geranium *pyrenaicum* and many other species, to from 33-34 degrees centigrade, causes them to fall. . . within a few minutes or even seconds—and the older the flowers the sooner they fell.

On the other hand such a sudden heating had no influence upon other flowers, such as roses and poppies. . . Furthermore, chemical influences were surprisingly effective in the case of some flowers, *e.g.*, carbon-dioxide in certain conditions, even in such small quantities as those contained in exhaled human breath—and this in some cases within a few minutes or even ¾ of a minute. . . . But in other cases carbon dioxide exerted no effect even in much higher degrees of concentration. . . . Illuminating gas was likewise found to be effective, but more slowly (though even immeasurable traces exerted an effect); other substances exerting a withering effect sometimes in very small amounts are tobacco smoke, fumes of chlorine or ether—also highly concentrated fumes of hydrochloric acid.

These various experiments indicate that different flowers vary greatly in their sensitiveness to a given irritant. Another remarkable fact is that certain blossoms fall very soon as a result of violent shaking.

In all the influences mentioned it is a general rule that the petals of the oldest flowers are the first to fall. . . . And in all these cases it is not a *vital process* but an *irritation* that is concerned. Furthermore, the irritation may be too feeble to operate—also there is a culmination of irritation, a latent period, and a possibility of becoming accustomed to the irritation; in short all the characteristic features of irritation processes are present. . . . Similar irritations have been observed to operate in the case of foliage. . . .



a b a b
Fig. 10. Fig 11.

10: Phalaenopsis amabilis, front view of style; *a*, before pollination; *b*, six days after. 11: Arachnanthe sulingi (a species of orchid); *a*, front view of ovary and style before pollination; *b*, ovary seven days after pollination

It is evident from our experiments that fertilization itself acts as a sort of irritant or stimulus. But the question remains as to what part of this complex process constitutes the actual irritant—and this remains obscure even after a careful analysis: Thus the germination of the pollen grain often begins in a few minutes with the formation and penetration of the pollen tube into the ovary, where the ova are fertilized.

[We are obliged to condense a portion of Professor Fitting's article at this point, both because of our space limits and because of its technical nature, which consists largely of a detailed discussion pro and con of the question as to whether the phenomena of post-florescence are directly due to the fertilization of the ova by the pollen tubes. We may state in brief that while the actual fertilization of the ova does induce the phenomena of post-florescence, these can be produced within a certain limited extent by the ungerminated pollen or even by dead pollen, as well as in certain cases by a pollen from a plant of a different family which is, of course, incapable of fructifying the ova.

As a result of these various observations and experiments by himself and other investigators, Professor Fitting was led to the remarkable discovery that in certain cases the post-florescent changes are due to the presence of *hormones* such as have long been known to be operative in the animal economy.—EDITOR.]

THE EFFECT OF PLANT HORMONES

These effects (the withering of the corolla, the swelling and lengthening of the ovary, etc.), are due to a substance which is present only in the pollen, and which clings to the latter externally; this organic compound, which is obviously not strictly specific in operation, is readily soluble in cold water and somewhat more difficultly soluble in cold alcohol, while it is quite insoluble in chloroform, petroleum, ether, and sulfuric ether; it cannot be precipitated by lead acetate and is, to all appearance, quite free of nitrogen.

This discovery gave certain proof for the first time that the substances known as hormones, which play so great a part in the animal organism, likewise exert a definite stimulus in one of the processes concerned in plant development.

Later observations, however, indicated that this fact which was discovered by me in my studies upon orchids, is not of general application. In other words that the ungerminated living or dead pollen does not exert a similar effect in the case of all plants.

An interesting observation was that the hormone present in the ungerminated pollen acts upon the corolla in a manner similar to the wounding of the surface of the stigma described above, *i.e.*, that it operates at a distance through the style, whereas the germinated pollen tubes are incapable of causing the swelling and growth of the ovary in this manner, as is shown by the fact that they do not produce this effect when prevented from passing through the lower portion of the pistil channel into the ovary.

From all these observations we may gain the practical knowledge that the longer we desire to enjoy the beauty and charm of flowers in our dwellings or elsewhere, the more careful we must be to protect them from all those influences whose effect is to make them wither prematurely. Among these influences we must include, as stated above, pollenization, traces of illuminating gas, tobacco smoke or air exhausted by breathing, too strong and sudden a heating in the sun, etc.; with respect to pollenization it must be remembered that one way of preventing it is to exclude the visits of humming birds, butterflies, bees, and other insects, whose special function, so far as the plant is concerned, is to secure the arriving of the pollen upon the surface of the stigma.

In connection with the above consideration the important question arises as to whether there is any means of *lengthening the specific absolute persistence of the blossom.* The beautiful orchids of our hothouses give an answer to this question. It is a very remarkable fact that there are some species of this family . . . in which the *same influence* which produces a premature withering in the case of other flowers, namely, the act of pollenization, considerably lengthens their absolute persistence. . . In various species of orchids studied by me, the result produced by pollenization was to cause the blossoms to remain fresh much longer, exhibiting no signs of alteration—*i.e.*, neither closing, withering, nor changing color—than in the case of non-pollenized flowers. Thus I was able to extend the duration of the *Zygopetalum* from one to three months and other species for double their usual time.

It is especially noteworthy in this connection that this effect was produced only by living and germinating pollen, whereas dead pollen, on the other hand, prematurely shortened the duration of the blossom. Here we have an instance of a prolongation of the life—not indeed of the entire organism—but at any rate of a portion of it, which is accustomed to undergo partial death.

This raises the further inquiry as whether it is possible to actually arouse new life in portions of the flower, which having arrived at the end of a specific absolute existence, have begun to show symptoms of morbidity—a question which has long occupied man with respect to his own body. As a matter of fact I succeeded in 1910, at least in the case of one species, the *Epidendrum ciliare*, in arousing new vital activity in the style (which had already begun to wither and yellow) by pollenization—*i.e.*, I caused it to swell and grow green once more, thus prolonging its existence for a considerable length of time.

The case appears to be quite similar with the above-mentioned blossoms of the *Phalaenopsis violacea*: When pollenized with living pollen the corolla begins to close, turn yellow, and to wither slightly, evidently under the influence of the hormone in the ungerminated pollen acting upon the stigma; but a few days later the corolla again becomes firm and fresh, begins to become green and renews its growth evidently under the influence of the pollen tubes which have been meanwhile produced or as a result of actual fructification.

PLOTTING THE SURVEY

The roll of paper is taken off the instrument and cut up. Each sheet is gone over and the inclined distances reduced to horizontal by means of a traverse table; the horizontal distances being marked in red ink against each line.

A large piece of cartridge paper is pinned down on the drawing table and the paper disks from the instrument are tacked down to it by means of a spot of gum at each corner, a lead weight being left on the corners for a few minutes until the gum dries. Gum is more satisfactory than pins, as there is nothing to interfere with the parallel ruler.

A rolling parallel ruler is placed against the first line S.W. to 1 and run out to a suitable place on the paper, a line ruled and the distance scaled off (scale in this case 1:100) and so on with all the lines of the survey.

The traverse lines are traced off on a piece of tracing paper, which is placed over the working stope sheet with the survey nails and check marks coinciding; it is then held in position by weights, the offsets are plotted along each line and pricked through to the stope sheet. Any new check marks are also pricked through. The tracing paper is taken off and the pinpricks on the stope sheet joined up with a hard pencil. The heights are averaged up in sections and marked on the stope sheet.

The area of each section is taken out by an Amsler planimeter and marked on the sheet. The cubic contents of each section is calculated to the nearest meter, and the various sections added up.

This method of surveying is rapid and gives results quite accurate enough for the purpose. On a trial closed traverse on the surface on fairly level ground, with a periphery of 318 m. the closing error was 0.15 m. as close as could be scaled.

The weak point of the instrument as at present constructed is the method of taking vertical angles. One or two elementary points need special attention: (1) always to make sure that the marked end of the alidade is pointing in the direction of the survey; (2) after sighting, to be certain that the alidade is clamped; (3) to mark the numbers of lines on the paper in the direction of the survey, that is, on the right-hand side of the alidade and with the tops of the letters as close to its fiducial edge as possible, so that, in the event of forgetting to draw the line, it can still be platted by placing the parallel ruler against the tops of the letters.

The survey party consists of the surveyor, three picked native assistants and a boy. The second assistant goes on in front and sets up and levels the tripods; the surveyor stays by the instrument and carries it himself from tripod to tripod. Two assistants are required to hold the tape from tripod to tripod, while the chief assistant and the boy take the offsets to the face, which the surveyor notes.

While the surveyor is working underground, an assistant in the office is plotting the previous day's work. Two notebooks are used alternately. The working stope sheets (of which there is one for each stope) are 1:100.

This method of stope surveying is twice as rapid as the method it superseded, and more than twice as rapid in the plotting, besides being more accurate and involving less strain on the attention of both the surveyor and his assistants. It was used by the writer for all stope measurements at the Passagem mine from 1916 to 1919.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

MENTAL TESTS AND MANUAL LABOR

In the *Journal of Applied Psychology*, December, 1920, Mr. Arthur Otis, in an article on "The Selection of Mill Workers by Mental Tests," presents some surprising results.

At the close of his army service he installed a system of mental tests for prospective employees (both clerks and mill workers), in a silk manufacturing company. Bringing to bear this experience in mental testing in the army and schools he constructed two systems of intelligence tests, one for clerks and executives, similar to the Otis General Intelligence Examination, and a comprehensive performance intelligence examination somewhat similar to the performance tests used in the army for foreigners and illiterates. This latter was for all mill workers, a large percentage of whom were foreign or illiterate.

The clerical intelligence test proved to be of decided value in the selection of members of the office force and has been adopted for permanent use. The results of an extended tryout of the performance intelligence examination, however, are both startling and baffling and cast an ominous shadow over the future of strictly intelligence tests for manual workers.

The performance scale used in this connection consisted of 13 tests covering a wide range of mental and manual activity. The examination of an individual lasted on the average an hour. In all some 400 employees were tested. These were placed in three groups according to their productive ability ascertained by careful investigation. In the last analysis it was found that the correlation between intelligence and productive ability was zero! No amount of age grouping or length of service grouping would bring anything but zero out of the correlations..

Commenting on this result the writer says: "The tests did measure intelligence one may be perfectly confident. The ability of clerks in these tests were found to be distinctly above that of mill workers as a class. The intercorrelations between the several tests ranged between .40 and .75 denoting a 'reliability coefficient' for the whole scale of .97. When 13 widely varying tests tend strongly to measure the same ability that ability must be 'general ability' or intelligence."

Mr. Otis is not prepared to say that it is proved conclusively that there is no correlation between intelligence and efficiency in mill work, for various reasons. It cannot be asserted confidently, he says, that every examinee did his best on the tests. There was lacking the incentive that is present when an applicant seeks employment. These examinees were already employed and saw no purpose in the tests. Moreover, the rating in productive ability was not as refined as could be desired due to numerous difficulties which could not be overcome in making the ratings. Furthermore, it was not possible to test such individuals as had failed to learn to weave or spin or be worth employing in some branch of the industry. These might have shown a lesser intelligence as a group.

On the other hand the difficulties above mentioned are only such as would be expected to "attenuate" the correlations—to reduce the true correlations to, say, one-half or less. But a correlation must be pretty small in the first place if one-half or one-third of it equals zero! One is forced to conclude, therefore, that intelligence is a very unimportant factor in efficiency in silk mill work.

The psychologist can hardly rest content with such a conclusion without some sort of explanation, considering the known correlation between intelligence and clerical ability or executive ability, military ability, etc.

The conclusion drawn from these researches is that intelligence is not only not required for most operations in a modern mill, but may even be a detriment to steady efficient routine work. What qualities are required remains to be sought. They may be stolidity, patience, inertia of attention, regularity of habits, etc.

The field of industrial psychology as applied to manual labor is believed by Mr. Otis to be virgin soil.

GEOLOGIC CONCLUSIONS FROM GEODETIC DATA

In the Proceedings of the National Academy of Sciences for January, 1921, Mr. William Bowie directs attention to Some Geologic Conclusions That Are Derivable from Geodetic Data.

For a number of years, says Mr. Bowie, geodetic data were collected for the purpose of controlling surveys and maps and for the determination of the shape and size of the earth. But in recent years they are also extensively used in investigations dealing with geological and geophysical problems. These investigations have included data for the United States, India, Canada and a small part of Europe.

These investigations have proved that for the areas considered there is approximately the same mass in each column of unit cross-section extending from the surface of the earth down to a depth of, say, 75 miles. This statement is justified regardless of what the depth of compensation actually is, for the deficiency or excess of mass in a few miles at the depth of approximately 75 miles is a small percentage of the mass of the whole column. There is no evidence as to the manner in which the compensation is distributed vertically, but the uniform distribution, which was adopted in order to make the computations more feasible, is as logical as any other simple method.

Continuing, Mr. Bowie says that it has been found that large areas are in almost perfect isotatic balance, and that it seems to be very probable that an area of about 70 square miles, the area of one square degree at the equator, is very closely compensated.

A test was made to show whether the compensation of small areas of topography could be ignored without seriously affecting the results. This test shows that, for even very small areas, the topography is at least largely compensated. This is a most important conclusion, for by analogy no such mass as the sedimentary material forming the delta of a large river entirely escapes isotatic compensation as has been held by some investigators. It may be concluded that the evidence *available from geodetic investigations* indicates in the strongest way that land masses are in equilibrium and that this equilibrium exists in comparatively small areas. A natural inference is that land masses have been equally in equilibrium in former geologic periods.

"How then," asks Mr. Bowie "can an area of sedimentation at approximately sea level, of one age, be a mountainous area in a succeeding one?"

Discussing this question, he says: "Mountain formation by transportation of material horizontally from one column in equilibrium to another column in equilibrium could not take place without destroying the isotatic balance. Of course, material is transported from one column to another (surface transportation after erosion is not included in this statement) but this is when the columns are out of balance and the movement renews the isotatic equilibrium between the two columns. Mountain masses are not excess loads on the earth, as is proved by the existence of the isotatic conditions in mountainous regions, therefore the materials forming the moun-

tains were not moved horizontally to the region. We are forced to the conclusion that the mountains must result from vertical movements in the columns under them. The vertical movement evidently must be due to an expansion and consequent decrease in density in the material of the column."

And further: "When we consider that all extensive areas of recent sedimentation on which we have gravity stations are in isotatic equilibrium and that mountain systems formed in previous sedimentary areas are also in equilibrium, we have no alternative to the view that an actual expansion of the columns under the mountains has taken place.

"The objection will be raised that there is abundant evidence that there have been horizontal movements in the materials forming the mountains. This is granted but is it necessary to go far beyond the mountain area for the forces acting laterally which cause the observed horizontal movements? Can we not conceive that, in the uplifting of the mountains of the Appalachian and Himalayan systems, for instance, the vertically acting forces will cause the material to progress in the directions of least resistance and that these directions may be horizontal in some cases and in others at varying angles with the vertical?"

The conclusion is reached that during the period of sedimentation, material probably was laid down in irregular ways. In the process of uplift the rate of expansion would undoubtedly be different in different parts of the zone. The sediments being of varying thickness, the material on which the sediment has been deposited varies in composition and consequently in its resistance to uplift. Finally, there is cubical expansion of the material which must cause the material at the borders, but outside of the columns, to modify somewhat the upward movements of the expanding mass. The areas affected are not small for the area of the base of the Appalachian system is more than 1000 miles in length and is approximately 200 miles in width, on an average. Consequently, there seems to be sufficient space for the development of lateral movements within the area due to local causes.

THE MENDELIAN LAW AND TOBACCO

In the proceedings of the National Academy of Sciences for February, 1921, Messrs. Setchell, Goodspeed and Clausen gave an account of crossing certain varieties of *Nicotiana Tabacum.* The authors find that their results confirm the Mendelian principles of inheritance, and show that there is no difference between qualitative and quantitative characters.

In connection with a taxonomic study of the various species and varieties of *Nicotiana,* the authors became interested in the extremely varied assemblage of varieties, both botanical and commercial, included under the species *N. Tabacum.* They agreed in principle on the method of derivation of existing varieties, but held conflicting views as to which particular forms should be recognized as fundamental. The principle followed in attempting to unravel the problem of origin of cultivated forms was to determine which few historically old varieties possessed in various combinations all the characters exhibited by commercial varieties, and then to refer existing varieties to hybridization with resulting segregation and recombination of characters exhibited in the stem forms.

There was needed some definite information as to the Mendelian details involved in character differences within the species. Accordingly three crosses were actually made and studied at some length. In some cases derivative lines were carried into the tenth hybrid generation. The three crosses, all in reciprocal, were made in 1909 as follows: (1) *angustifolia x macrophylla,* (2) *calycina x virginica* (Maryland) and (3) *alba* (White) *x macrophylla.* Detailed descriptions of the above-named varieties have been given by Setchell in a previous paper.

A general result of these investigations has been a demonstration of the complexity of difference from a genetic standpoint between any two of these so-called fundamental varieties of *Tabacum.* This result demonstrates the futility of seeking to determine affinities on the basis of *morphological* studies unaccompanied by experimental investigations. Thus, for example, there are such puzzling segregation products as the *auriculata* and *lorifolia* leaf types, the former with its peculiarly constricted leaf base, the latter with a much narrower leaf blade than either parent, coming out of the *angustifolia-macrophylla series.* Moreover, the demonstration of the existence of genetically distinct red-flowering varieties is another evidence of the limitations of purely *morphological* studies and of the errors in the determination of affinities to which such studies are subject. The studies indicate that *Tabacum* is a group species like corn, barley, oats, etc., possessing a complex series of allemorphic contrasts.

Doubtless one of the reasons why our knowledge of the details of inheritance in *Tabacum* is so meager is because of the prevailingly quantitative or semi-quantitative nature of the character differences. Even in the case of flower color, the impression given by a series of varieties arranged in order of intensity from white to intense dark red is one of graduated differences in amount of a single pigment rather than in qualitatively different pigments. A definite alternative analysis can, however, be made even for these semi-quantitative characters by growing successive generations of segregating progenies until the progenies have been freed of segregation products other than those which it is desired to analyze. Furthermore, the establishment of constant derivative races and the subsequent study of intercrosses among them has been found to result in simplification of the difficulties of analysis. Both of these methods evidently depend upon stabilizing the residual genotype, which is a prime desideratum in the accurate analysis of semi-quantitative characters. The fact that such simplification of segregation can be accomplished and that semi-quantitative characters may then be subjected to analysis according to the qualitative mode of procedure argues not only for the adequacy of Mendelian principles in these cases, but for the identity in principle of qualitative and quantitative characters.

MUSCLE

In *The American Journal of Physiology* for May, 1921, Messrs. N. B. Eddy and A. W. Downs present an interesting paper on "Muscle, Its Extensibility and Its Fatigue." Reviewing the work bearing on their investigations the authors say in part:

"The extensibility of muscle was first systematically investigated by Weber in 1846. It was he who found that a muscle stretched by the addition of equal increments of weight does not follow Hooke's law. Its curve of extensibility is not a straight line but a hyperbola. Weber's findings have been confirmed beyond question. There are, however, some other organic substances, non-living, which do not follow Hooke's law when extended by weights. Therefore, is the muscle which is stretched by a weight purely passive, or, does it put forth an active effort to support the weight; that is, does the stretching of a living muscle involve an increase in its metabolism, an energy transformation, the doing of work?

"Guerrini considers the specific form of the curve of extensibility of muscle as affording evidence of a vital response in the muscle. He speaks of the later more gradual part of the curve as dependent upon the biological factor, arguing from the lessening or total disappearance of this part of the curve, that is, from the straightening out of the curve when the vitality of the muscle is lessened or destroyed. He cites particularly poisoning of the muscle by various means and fatty degeneration of the muscle as affecting the curve in this manner. Many observers are agreed that the extensibility of muscle is increased and that the curve more nearly approaches a straight line during contraction and with the development of fatigue.

"Brodie found that muscles *in situ* with intact nerve and blood supply were more resistant to extending forces, the

same weight caused less lengthening, than isolated muscles or muscles *in situ* whose nerve supply had been cut.

"Montgomery appears to have been the first to conceive the possibility that the stretching of a muscle may be accompanied by chemical as well as physical changes within the muscle. He did not, however, venture to reveal the nature of these chemical changes."

The authors took up the question at this point and carried out a series of twenty-five experiments with a view to determining the possible extent to which the stretching of a muscle may influence the development of fatigue.

Both gastrocnemius muscles were removed from a pithed frog as speedily as possible with especial care to avoid traction on either muscle. Each was fastened in the femur clamp of a separate moist chamber of the Harvard type and fine wires were run from the base of the moist chamber to the muscle for its direct stimulation. A pin-hook with attached thread was passed through each tendo Achillis. One was left free; the other was fastened to a muscle lever and made to support a weight of 100 grams for varying lengths of time. Subsequently each muscle was stimulated with an induced current to the point of complete exhaustion. In two instances a tetanizing current was employed; in all of the other experiments the stimuli were single break shocks. In the first seven experiments the stretched and unstretched muscles were connected in series in one secondary circuit of an induction coil so that both muscles were stimulated simultaneously. The strength of the stimulus was that which called forth maximal response in the unstretched muscle. The stimuli were sent in at the rate of one per second. The direction of the current in the secondary circuit was varied so that in some experiments the stretched muscle and in others the unstretched muscle was first traversed by the current.

The stimulation of the stretched muscle was always carried out immediately upon the removal of the weight. The muscle was always left attached to the muscle lever and sometimes additional 20 or 30 grams were suspended from it. The unstretched muscle was connected to the muscle lever just prior to its stimulation and a load of 20 or 30 grams added if necessary to make the conditions uniform. Usually the writing point of the muscle lever was brought against the smoked surface of the kymograph and the contractions recorded. The time required to effect complete exhaustion of each muscle was determined with a stop-watch.

The results of the experiments are presented in a table, and the conclusion is reached:

These results would seem to be sufficiently marked to justify the conclusion that a previous stretching hastens the onset of fatigue in a muscle. This is not due simply to an alteration in the irritability of the muscle since the average minimal stimulus is slightly weaker for the stretched than for the unstretched muscle. Obviously there is no opportunity for the isolated muscle to replenish its store of energy-yielding material and the using up of some of this by the muscle in combating the stretching force would hasten the development of fatigue since fatigue is not only an accumulation of waste products but also an exhaustion of energy-yielding material.

BIOCLIMATICS

In a paper published in the *Journal of the Washington Academy of Sciences* and read before the Academy of Sciences, Washington, Dr. A. D. Andrews discusses the interesting subject of Bioclimatics.

"*The bioclimatic law*," says Dr. Andrews, "Is a law of life and climate as related to the geographical coordinates *latitude*, *longitude* and *altitude*. It includes, as one of its principles, an average, or constant, rate of variation with variations in geographical positions, as manifested by the advance of the seasons and coincident phenomena, and by the geographical distribution of living organisms and types of climate."

The subject is largely one of the relations between life and climate, with regard to the original home of a species, the environments under which it has developed, the range and limits of its natural distribution on one continent, the place of its artificial introduction to another, its establishment there, and its natural or artificial spread from the point of entry.

In accordance with this law the country-wide average rates of variation in time, temperature, and distance, as related to periodical phenomena, geographical distribution, range and limits of zones, etc., are represented by the unit constants of 4 days to each equivalent constant of 1 degree of latitude, 5 degrees of longitude (or 1 degree isophane), 400 feet of altitude and 1 degree Fahr. of the thermal mean. These unit constants are equivalent, one to the other, and, therefore, the terms of one unit may be converted into those of another as required in the computation and expression of results.

The application of the law to the study of any problem relating to life or climate in which the elements and data are subject to expression in terms of quantity, as to time, temperature, and distance, falls within the category of a mathematical concept of variable nature and, therefore, in the solving of bioclimatic problems, involves the determination of certain evidence and facts by mathematical methods.

In the application of the law certain principles are involved, namely:

(1) *The principle of geographical unit constants* which relates to rates of variations or gradients of time, temperature, and distance, with variations in geographical position.

(2) *The principle of the isophane and altitude* in which the isophane is an expression of the combined unit constant of the latitude and longitude coordinates while the altitude unit constant is a measure of variation with elevation of a place above its sea-level isophane in terms of time, and equivalent units of feet, meters, thermal mean, etc. This principle is fundamental.

(3) *The principle of the sea-level constant.* This represents a uniform element of the system of computation of tables of altitude, time or thermal constants in accordance with the unit constants of the law.

(4) *The principle of the base station and base data.* This principle, in connection with that of the sea-level constant, serves as a central or basic element of a uniform system of computation and comparison of quantities.

(5) *The principle of the constant and variable.* This relates to the study of variability with reference to a "constant" as the measure of the relative intensity of the factors of variation.

(6) *The principle of equivalents* as related to equal unit values of certain elements of the law and of the system of application, such as the geographic unit constants.

(7) *The principle of the average or norm* as related to variable quantities.

(8) *The principle or law of averages* as related to the compensation of errors in reported dates of events, temperatures, general computation of data, etc.

Discussing the results of the application of these principles, Dr. Andrews says:

"In a general comparison of the results of the study as to the relations between the predictions and the actual dates, etc., it is concluded that the significance of the results of this study, is in showing not only the relations between eastern North America and western Europe, as to the relative advances of spring, but the general range of variations, of the recorded dates and thermal mean equivalents, from the dates, and from the thermal means, predicted from an incontinental base. These results indicate, as nothing else has heretofore, the amount of regional and local difference in days to be expected for a spring event between a place in eastern North America and places in western Europe.

The results relating to the prediction of bioclimatic zones represented by the recorded dates and thermal means are of special significance in indicating the zonal relations between eastern North America and western Europe and in showing that the law may be applied to the preliminary prediction

of zones of equal adaptation to certain species and varieties of plants and animals, farm and garden crops, as a guide to the successful introduction of desirable species and varieties, and the prevention of the introduction of pests from one to another part of the world. These, together with the results relating to variations in equivalent days and to the variations of the recorded from a constant thermal mean, are new.

In conclusion the writer says: "The general results of this study of an intercontinental problem in bioclimatics should leave little or no reasonable doubt as to the fact of, and prevailing responses represented by, the bioclimatic law. Neither should there be any doubt as to its practical application to almost any problem in any branch of natural science which involves a consideration of the responses of living organisms and climatic elements to continental, regional and local influences, or to problems that require a measure of the relative intensity of the factors of variations as related to periodical manifestations and geographical distributions."

THE STRUCTURE OF CRYSTALS

In the *Journal of the Washington Academy of Sciences* for May 19, 1921, Dr. R. W. G. Wyckoff discusses methods for The Determination of the Structure of Crystals.

An outline of the developments of the methods thus far used, the author says, serves to show the point of view from which the studies of the arrangement of the atoms in crystals has been carried out. The essential steps in this development are the experiments of Laue and of the Braggs, the determination of the arrangement of the atoms in some one crystal and the consequent measurement of the absolute wave lengths of X-rays. In nearly all of the structures which have been studied a procedure based upon the point of view of these experiments has been followed. This procedure consists in getting a limited amount of experimental data with the aid of one of the three existing methods of obtaining diffraction effects—the Laue method, the spectrometer method or its modification, and the method of powders. Bearing these experimental facts in mind, the analyst has tried to imagine some arrangement of atoms which will explain them. If he has succeeded in devising such a grouping, it is considered to be the structure of the crystal. This method of procedure is both cumbersome and haphazard and there is no means of knowing whether many other ways of arranging the atoms of the crystal under examination do not exist, all equally capable of explaining the data.

Mr. Wyckoff contrasts this method with that method which can be built around the theory of space groups. The results of this geometrical theory can be given an analytical representation which states in terms of suitable coordinates all of the positions in space that atoms in crystals can occupy. With its aid, and knowing the crystallographic symmetry, it is thus possible to write down in the case of any particular crystal, independently of any X-ray experimentation, all of the ways in which the atoms can be arranged. Suitable calculation will give the kind of diffraction effects to be anticipated from each of these possible arrangements of atoms. The experimenter may then obtain, by whichever of the various methods will yield the desired information most readily, those data which the calculations show to be necessary to distinguish between the possible atomic groupings.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

HARDENING OF METALS

Jeffries and Archer have made an important contribution upon the theory of metal hardening in their paper entitled "The Slip Interference Theory of the Hardening of Metals." The paper which is extensive and illustrated appears in full in the June 15th number of *Chemical and Metallurgical Engineer* from which the following summary is quoted:

"A complete theory of hardening must explain hardness in non-allotropic metals, a task which has been attempted in the preceding pages, and is summarized below:

"1. The inherent cohesion of the pure metals is far in excess of values obtained for tensile strength.

"2. Mechanical failure under stress is ordinarily premature because of the presence of crystallographic planes of weakness, or potential slip planes.

"3. Any structural condition which interferes with slip on these planes of weakness increases the strength and hardness of the metal. Furthermore, every known method of hardening metals can be referred to this principle of 'slip interference.'

"4. In a pure metal the most simple source of increased hardness is grain refinement, which introduces slip interference at the grain boundaries due to the different orientations of the adjacent grains, and, especially in fine grained metals, to the disorganized or amorphous metal between the grains.

"5. Cold-working introduces slip interference by the fragmentation of the grains and the production of amorphous metal.

"6. The hardness and strength of amorphous metal itself is due to the absence of the planes of weakness characteristic of crystals.

"7. Slip within grains is opposed by the presence of a strong constituent at the grain boundary, providing that if the strong constituent is brittle, its shape and size are not such as to lead to effective weakness due to eccentricity of loading.

"8. Effective hardening is obtained by slip interference within the grains, due to the presence of hard constituents uniformly distributed in the form of very fine particles.

"9. It is not necessary that the hard constituent possess great adhesion for the matrix.

"10. The effect of a given amount of hard constituent increases with the fineness of subdivision, reaching a maximum at an average particle size denoted by the term 'critical dispersion.' The critical dispersion probably consists of the smallest particles having the characteristic properties of the crystalline substance. The order of magnitude of the diameter of such particles is probably about 10^{-7} cm. A higher degree of dispersion, particularly the atomic dispersion of solid solutions, is less conducive to hardness.

"11. Corresponding to the maximum hardness at critical dispersion, there is a minimum in ductility.

"12. Increase in the amount of dispersed substance produces increased hardness, but the brittleness also increases, so that there is a limit to the useful hardness and strength that can be obtained.

"13. The amount of hard dispersed substance which produces the greatest useful strength increases as the size of particle increases.

"14. The actual amounts of hard dispersed substances which produce useful results are from about 2 to 15 per cent by volume.

"15. The only manner in which the high degrees of dispersion desired are produced consists in the limited decomposition of solutions, and in particular of solid solutions.

MICROANALYTICAL METHODS IN OIL ANALYSIS

Microanalysis presents so many advantages that it seems remarkable that more attention has not been given to developing its technique, considering its field of usefulness. There have been a few outstanding investigators who have devoted years to this subject; but the average analyst is too prone to call for larger samples of an unknown and is too little interested in the development of methods whereby a reduction in the quantity required for analysis can be secured. In many cases the quantity available for analysis is distinctly limited. It is therefore interesting to note the work reported by Gill and Simms under the title "Microanalytical Methods in Oil Analysis," which has just appeared in the June issue of the *Journal of Industrial and Engineering Chemistry*. The authors show that an accurate proximate analysis may be made upon oil when only a few drops are available and that this work can be done with an accuracy comparable to that obtained by the usual methods.

Four oils of widely different properties were selected, these being olive, lard, cottonseed and raw linseed, and the tests to which most attention was given were the iodine number, saponification value, and specific gravity.

Those interested should consult the original article for details. Very close analytical results on the saponification and iodine values of oils are obtainable with 15 milligrams of the sample or about 1/100 the usual amount required for the first determination, and 11 milligrams, which is from 1/14 to 1/27 of the usual sample for the second determination. Good results for specific gravity are obtainable with one gram samples and the apparatus used throughout the experiments was that ordinarily to be found in the laboratory or easily made by a good manipulator.

The extent to which the investigators carried their work is shown by the attempt to make two or more determinations on the same drop of oil. For example, it was thought that it might be possible to get the refractive index on a drop or two of oil, absorb the oil on filter paper, obtain the saponification value, and then get the melting point of the fatty acids and their iodine value. However, no success attended these attempts.

In specific gravity work a new type of hydrometer was devised, consisting of two bulbs, the lower one being the usual hydrometer bulb while the upper one, not connected with the lower, is to be filled with the oil or other substance whose gravity is desired. This bulb has a small side tube which is dipped into some of the substance placed on a flat watch glass and the sample is then drawn through the stem, which is open at the top. The bulb is filled to a little above the mark on the stem with the liquid which is then drawn down to the mark by means of a piece of filter paper applicable to the end of the short tube. A soft rubber stopper with a small hole in it is then placed on the end of the stem to prevent the entrance of water in the bulb by capillary attraction when the bulb is immersed in water. The bulb having been filled with the oil the hydrometer is immersed in water in a two liter graduate. The height of the hydrometer in the water is observed by reading on the scale of the graduate the height of the bottom of the hydrometer. In this way it is not necessary to calibrate the stem of the hydrometer and a smaller stem may be used. This is important since the sensitiveness of a hydrometer may be taken as inversely proportional to the diameter of the stem squared. Hence to make a hydrometer sensitive it is necessary to make the stem as fine as practicable.

The bulb is emptied by blowing through the stem and is rinsed out with alcohol and ether.

The method is very simple and no weighings are required. The chances of error are smaller, since there is always danger of a large error in weighing a glass vessel, owing to the absorption of an appreciable layer of moisture, the amount depending upon the humidity of the atmosphere. When the hydrometer described has been calibrated by filling the bulb with water, taking a reading, and then reading it with oil of known specific gravity and calculating a factor for the hydrometer in use, one reading is sufficient. The only source of error lies in reading the scale, provided only that care is exercised in filling the bulb exactly to the mark on the stem and there is not too much variation in temperature. The error in reading the scale on the cylinder is negligible if the gradations pass all the way around the cylinder. The time required was found to be less than that which is necessary in the use of a pycnometer and, as in the latter case, the oil may be recovered and used for other determinations. The authors have given the name of gravitometer to this new piece of apparatus.

STORAGE AND DEHYDRATION OF VEGETABLES

Gore and Mangels of the Bureau of Chemistry of the United States Department of Agriculture have contributed two articles in the June number of the *Journal of Industrial and Engineering Chemistry* which will be of interest to those concerned with the storage and dehydration of vegetables. It has been found that the moisture content of dehydrated raw vegetables is a factor of considerable importance for successful storage even in airtight containers at ordinary temperatures. A series of experiments was undertaken to determine the critical moisture content for several important dried vegetables below which the changes in color and flavor, on keeping at ordinary temperatures, are very slow. These experiments were begun in 1917, some of the material being dried early in 1918, and included carrots, turnips, onions, spinach, and cabbage.

Carrots of 11.11 per cent moisture faded distinctly during sixty-eight days' storage while those of but 7.39 per cent moisture kept well for the same period. Turnips of 11.51 per cent moisture browned distinctly and developed a peculiar odor in thirty-three days while those dried to 5 per cent moisture had not changed in eighty days. The same general facts were confirmed in the case of the onions, spinach, and cabbage.

The initial moisture content at and below which the distinctive color and flavor are well retained for six months or more were found to be as follows:

Carrots	4.99 to 7.39%
Turnips	5.00%
Onions	5.74 to 6.64%
Spinach	3.81 to 5.38%
Cabbage	3.00 to 3.34%

The effect of heat on different dehydrated vegetables has also been investigated, the object being to determine, if possible, limits of tolerance for different vegetables and also to determine the importance of three varieties: first, the degree of heat used; second, the time of exposure to this temperature; and third, the relative humidity of the surrounding air. The dried vegetables studied were classed as follows in regard to sensitiveness to heat:

Very easily injured: Onions, turnips, celery, tomatoes, cabbage.

Fairly resistant: Carrots, string beans, sweet corn.

Very resistant: Sweet potatoes

As the degree of temperature increases the exposure necessary to cause injury decreases, and an exposure in an atmosphere of comparatively high relative humidity at the lower temperatures was found to be more injurious than the same exposure in a dry atmosphere. The following detailed results of these experiments is quoted:

String Beans.—No injury resulted from 18 hours' exposure to dry heat at 55° C., and injury was doubtful at 60° C. Moist heat caused no injury in 20 hours at 50° C., but injured the beans in from 9 to 11 hours at 60° C. At 90° C., both dry and moist heat injured the beans within 1 to 2 hours.

Cabbage.—In dry heat, cabbage was injured in 16 to 20 hours at 50° C., in 12 to 14 hours at 55° C., in 3.5 hours at 70° C., and in 1 hour at 75° C. In moist heat, injury occurred in 6 to 8 hours at 50° C., in 5 hours at 60° C., and in 3.5 hours at 70° C.

Carrots.—Carrots are not easily damaged by overheating, and in this respect are comparable to string beans. Moist air at 50° C. injured the carrots in from 17 to 18 hours, while at 60° C. injury occurred in from 8 to 9 hours. In the dry atmosphere no injury occurred in 18 hours at 60° C. At 65° C., the product was injured in from 10 to 12 hours. The moist heat curve was consistently below the dry heat curve and gradually approached it at higher temperatures.

Celery.—Celery may be classed with the easily injured vegetables. In a moist atmosphere at 50° C., injury occurred between 6 and 8 hours. In a dry atmosphere, no injury was found at 20 hours' exposure. At 60° C. injury occurred after 4 hours' exposure. The moist heat line was consistently under the dry heat line to 80° C., where they coincided, injury being found after 30 minutes' exposure. The observations coincided again at 90° after 10 minutes. Celery is especially susceptible to color changes in a moist atmosphere at low temperatures.

Onions.—Onions are very susceptible to heat, both dry and moist. In a dry atmosphere, the injury occurred after 12 to 16 hours' exposure at 50° C., while in a moist atmosphere injury occurred after 8 to 10 hours at this temperature. Injury occurred in 6 hours in a dry atmosphere at 55° C., and in 5 hours at 60° C. In a moist atmosphere at 60° C. injury occurred after 4 hours. From 70° up to 90° C., dry and moist heat had about the same effect. Injury occurred very quickly (in 10 minutes) at 90° C.

Potatoes—Shredded and Blanched.—Potatoes are not especially susceptible to heat injury. The injury is very easily detected on account of the light color and translucence of the pieces. Moist and dry heat had about the same effect, except at the lower temperatures. In dry heat injury occurred after 16 hours' exposure at 50° C., in 11 hours at 55° C., and in 8 hours at 60° C. In a moist atmosphere injury occurred after 11 hours at 50° C., and in 7 hours at 60° C.

Potatoes—Diced.—Diced potatoes have almost the same resistance to heat as the blanched, shredded potatoes. The endpoint is not so easily distinguished.

Sweet Potatoes.—Sweet potatoes are very resistant to heat, as compared with the other vegetables. In a moist atmosphere at 90° C., injury occurred in from 8 to 12 hours. No injury after 10 hours was found in a moist atmosphere at 80° C. In a dry atmosphere at 90° C. injury occurred after 5 hours, and after 10 hours at 80° C. Temperatures lower than 80° C. did not seem to injure sweet potatoes, at least not for many hours.

Sweet Corn.—Sweet corn is fairly resistant to heat, being more resistant than carrots, although not so resistant as sweet potatoes. Moist heat in general is more harmful than dry heat. In a moist atmosphere at 50° C. no injury was found after 20 hours' exposure. In a dry atmosphere at 60° C., no injury was found after 20 hours' exposure, while in a moist atmosphere at this temperature the product was injured by 10 hours' exposure.

Tomatoes.—Tomatoes are easily injured by heat at 60° C. and above. The peculiarity of the tomato results was that at 70° C. and above moist heat was less injurious than dry heat. At 50° C., tomatoes were injured by between 8 and 10 hours' exposure in a moist atmosphere, while they did not show injury until after 16 to 18 hours' exposure in a dry atmosphere. The resistance to dry heat decreased rapidly, however, as the temperature rose, and at 60° C. injury occurred after 6 hours' exposure.

Turnips.—Turnips are easily injured by heat, and may be classed with celery, onions and tomatoes. At 50° C., in a moist atmosphere, injury occurred after 8 to 10 hours' exposure, while with a dry atmosphere they had to be exposed 16 to 20 hours before injury was noticeable. The resistance to dry heat decreased very rapidly, however, and at 60° C. the material showed injury after 5 hours' exposure.

CREOSOTED WOOD SILOS

The wood-preservation studies at the Forest Products Laboratory have shown that the value of wooden silos can be greatly increased by proper treatment with coal-tar creosote. A good creosote treatment will not only increase the durability of the wood, but will reduce the tendency of the staves to shrink when the silo is empty. A creosoted silo cannot be painted afterward; however, it does not need painting for the creosote protects the wood, and its color is pleasing.

Highly durable woods, such as heart cypress or redwood, do not need protection against decay so much as the non-durable woods, but a thorough creosote treatment will make the non-durable woods, such as sap pine, last longer than durable species will without treatment.

Contamination of the silage by creosote from the staves need not be feared. This is borne out by experiments and by careful inquiry among the many farmers who have used creosoted silos. In order to be quite sure, it is well to allow the creosoted staves or the finished silo to stand a few weeks before filling.

The most thorough creosote treatment can be given by pressure methods. If pressure-treated wood is not available, very good results can be obtained by the hot and cold bath treatment. If a good penetration of coal-tar creosote is obtained by either of these processes it is not too much to expect the silo staves to resist decay 25 or 30 years.

Other methods of creosoting, such as painting, spraying, or dipping can be used. They are less costly than the pressure treatment, but they are also less effective. They will probably add several years to the life of the silo and thus pay for themselves, but the more thorough treatment should be used wherever possible. Instructions for treating silo staves by these various processes may be obtained from the Forest Products Laboratory, Madison, Wisconsin.

GLOVE CLEANING AND DYEING

O. S. Bagger in the *National Cleaner and Dyer* gives practical information on how to obtain good results when cleaning, tinting, and dyeing gloves or other leather articles. Gloves are cleaned either by machine or by hand. Depending upon the condition of the material the gloves are thoroughly washed in a strong solution of soap from half an hour to an hour. Gray and brown gloves, lined gloves, and gauntlets are always brushed by hand. After this washing those which have perspiration stains, or are still stiff, or soiled, are then brushed with wood alcohol until the stains are gone or, in case they are very soiled, they are immersed in the alcohol and rubbed between the hands until soft, or benzine and soap is used with the alcohol. The alcohol is then removed by a further washing in soap and water. Ink stains, if present, are removed by alternate treatment of the spots with ammonia and oxalic acid dissolved in alcohol, with a final washing in alcohol to remove every trace of the acid.

Next, the gloves are wrapped in a perfectly clean cloth or put in a bag and lightly extracted with gasoline or naptha. The drying and finishing of the gloves is important. Where a small number are being cleaned they are simply blown out with the breath, after extracting, and hung up to dry on a clean line. When dry they are rubbed very lightly with talcum powder upon cloth and then stretched and smoothed by pulling over the sharp edge of a table. Where large quantities of gloves are handled they are dried in a special contrivance for the purpose and then finished on a heated metal form. Another way is to put the gloves, after extraction, on wooden or metal glove hands which have four fingers with slots between them. The gloves are smoothed out by hand or with a clean cloth and hung up to dry on the forms, the thumb being smoothed out by the worker. When dry they are rubbed with

the talcum powder. Long gloves are better pressed under tissue paper with a warm iron.

In cleaning colored gloves some of the color will be removed no matter how careful the operator has been, and retinting will be necessary. There are a number of excellent preparations for this purpose on the market, and some cleaners find it advisable to have a number of powders in colors, in stock, such that they can be mixed to produce the desired shade on short notice. A gray powder, for example, is prepared by dissolving about two ounces of fat black in half a pint of alcohol. One liquid ounce of aniline is added and sufficient auramine until the sample shows a good dark gray. Precipitated chalk is stirred until a thick paste is formed, and this paste is left in a warm place until all the alcohol has evaporated when the mass is reduced to a powder in a mortar. From this powder any shade of gray can be produced by the addition of more white or colors, the mixing being done in the mortar to secure a uniform shade. Other colors can be produced in a similar way.

The powders are applied with a piece of cotton and, after powdering, the gloves are beaten slightly in the hand to remove any excess of powder while in the case of glazed kid they are rubbed with the hands to restore, in some degree, their original gloss.

While some object to dyed gloves because the color rubs off, Mr. Bagger gives a formula for the preparation of a dye liquor which in his experience practically eliminates this trouble. Six ounces of fat black, one-fourth ounce of yellow, and one-eighth ounce of orange, all soluble in alcohol, are dissolved in one pint of aniline oil over a fire, and one pint of methanol is added. This solution is kept in a tightly stoppered bottle and small portions poured out as needed. Gloves first cleaned in benzine and dried have the color applied by means of a camel's hair brush, each finger being treated separately on a glove stick. The penetration of the dye to the inside of the glove is avoided by using small quantities on the brush and applying it with long, light strokes. The glove, when dried, is of a grayish blue color which polishes to a good black. More than one coat is sometimes necessary. While polishing is often done with some oil, such as olive oil, this is objectionable because of the sticky, greasy feeling. A better method is to use ordinary black shoe polish, although the color of the shoe polish may rub off to a slight extent. The best way seems to be to treat the glove with a colorless dressing which may be prepared by melting four parts of wax, four parts of olive oil, and one part of lard. To this is added a small amount of turpentine and a few drops of oil of lavender. The mixture is stirred well and, when cool, forms a colorless plate which will make gloves soft and glossy and practically prevent color from rubbing off. Suede gloves are more difficult to dye; but a fair result may be obtained by using a dye liquor prepared without the aniline oil and, instead of rubbing them, powder them with a black powder prepared in the same manner as the gray powder previously described.

When dyeing shoes, as much of the original dressing as possible should be removed, for otherwise the dye cannot penetrate uniformly, and in all cases several coats will be necessary. Suede tops should be treated in the same manner as suede gloves.

Satin slippers are dyed to the desired shade with basic dyes soluble in alcohol, and the shade is first obtained on a sample of white satin. After obtaining the shade the solutions to be used are greatly diluted and a number of light coats applied, since it is practically impossible to remove any excess color. The dye is applied with a cloth, working quickly to obtain even dyeing. When dry, the slippers may be rubbed off with a cloth slightly dampened with olive oil.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

MICROSCOPIC STUDY OF GRAPHITIZATION IN CAST IRON

During the past year an investigation of graphitization in cast iron, designed to supplement that reported in Technologic Paper, No. 129, has been in progress. The micrographic study of the various specimens which have been subjected to prolonged annealing has been completed. The results indicate that considerable graphitization, that is change in the combined carbon, occurs in the material below the thermal critical range (approximately 700° C). Below 500° C., however, no change was detected after a very long heating period. The microscopic study reveals many interesting and valuable facts which are not brought out by chemical analysis alone. Thus, in the low-temperature graphitization, only the pearlite is affected, the free carbide does not appear to be changed until the thermal critical point has been passed and solution of this constituent has begun. The form in which the graphite exists after annealing depends upon the initial structural state of the iron. If any flakes of graphite exist they act as nuclei for the deposition of the graphite formed during annealing, while if no such flakes are present the new graphite takes the form of small globules rather than flakes.

STANDARDIZATION OF BUTTON SIZES

There is a real need for standardization in our button industry, and the Bureau has been looking into the question to see whether something cannot be accomplished that will lead to the elimination of useless sizes and thus reduce manufacturing costs. The possibility of eventually standardizing the materials used in the making of composition buttons is also being considered. Buttons are at present made in many thousands of patterns, finishes and colors and there are also a great many different sizes now in use. Many makers have their own particular line of sizes and grades, and in the past it has been hard for different manufacturers to match each other's product. But many in the industry feel that the specification of standard sizes, at least, is a possible step forward, that will benefit both the trade and the public, and the National Association of Button Manufacturers has requested the cooperation of the Bureau of Standards in the furtherance of this project.

There is a great variety in the sizes of buttons, ranging from an 8 line, one-fifth of an inch in diameter, to an eighty line, two inches in diameter. Instead of referring to button sizes in fractions of an inch or in millimeters, it is the custom, borrowed from England in the early days, to number them according to their size in lines, one line being considered to represent one fortieth of an inch. The Gage Section of the Bureau has obtained the size standards of several of the largest manufacturers and has evolved a proposed national standard scale which eliminates one-fifth of the usual number of sizes used by each manufacturer and discards an even larger number of the total different sizes used. Clothing manufacturers and other users of buttons will be consulted as to how the proposed changes affect their work and their recommendations followed wherever possible.

ETCHING REAGENTS FOR FERROUS METALLOGRAPHIC SPECIMENS

WORK on the above subject has been carried out on a series of 15 chromium steels, ranging in chromium-content from 0.5 to 22.5 per cent, and in carbon-content from 0.3 to 1.5 per cent, and which were all given approximately the same heat treatment (annealed at 900°-1000° C. and very slowly cooled). The results indicate that as shown by the structure developed by etching with 2 per cent alcoholic HNO_3 the number of very small globules of carbide thickly distributed through the matrix appears to depend upon the carbon-content—that is, the higher the carbon-content up to about the eutectoid point, the more numerous the carbide globules are—and to be independent of the chromium-content in excess of that needed to combine with the carbon. Etching with Murakami's reagent (solution of potassium ferricyanide and potassium hydroxide) does not appear to bring out to the same extent the presence of the very small carbide globules that etching with HNO_3 does, although the larger carbide particles are brought out to the same extent by both etching reagents.

Experimental work is now in progress to determine at greater length the extent to which the darkening of the carbide globules is brought out by etching with Murakami's reagent at room and at boiling temperatures.

In connection with the trying out of new etching reagents, it may be mentioned that a solution of potassium permanganate and potassium hydroxide (used hot) was found to give similar etching results as Murakami's reagent (used hot) with chromium and high-speed steels.

TENSILE PROPERTIES OF STEELS AT ELEVATED TEMPERATURES

THE investigation of the properties of low-carbon steel, such as is used in boiler construction, which has been in progress for some time has been completed, and the results are being prepared for publication. The title under which this paper will be issued will probably be "Effect of Temperature, Deformation, and Rate of Loading on the Tensile Properties of Low-Carbon Steel Below the Thermal Critical Range."

STRESSES IN STEEL CAR WHEELS

AT the suggestion of one of the manufacturers who has been cooperating with the Bureau in this investigation, some special "runs" were made in which strain measurements in both radial and tangential directions on both faces of the wheel were taken. The results indicated that no tangential stresses are set up in the wheel as a result of heating. On the front side of the wheel tension near the hub and compression near the rim exist, while stresses of equal magnitude, but of opposite sign, exist on the other side. This stress distribution appears to be the result of the conical shape of the wheel. Similar tests will be made on the wheels submitted by each of the other manufacturers who are working with the Bureau in these tests.

TURBIDITY OF WATER

THE Bureau is investigating the question of a turbidity standard for water supplies, at the request of the Joint Committee on Standard Methods of several of the large American technical societies. The possibility of using settling curves for the specification of the size of particles in suspension is also being considered. A report on this work was recently made before the Annual Convention of the American Water Works Association at Cleveland.

ELECTROPLATING INVESTIGATIONS

AT the recent annual meeting of the American Electroplaters' Society, three papers were presented by members of the Bureau's staff who are engaged in research on electroplating. These were:

(1) Use of Fluorides in Nickel Deposition.
(2) The Acidity of Nickel Solutions.
(3) Electrolytic Reproduction of Engraved Printing Plates.

The last-named paper described the interesting work which the Bureau has been conducting in cooperation with the Bureau of Engraving and Printing, a complete plant for producing printing plates by this new process having been installed at the Bureau of Engraving and Printing under the direction of the Bureau of Standards. The discussion of these and other papers at this meeting shows that there is increased appreciation of the value of research work in this field, and indicates that there will be a growing demand for such research from commercial electroplaters.

GLASS SPECIFICATIONS

FOR some years the Bureau has been engaged in research work dealing with optical glass and has assisted in the preparation of many specifications to govern the purchase of this material. More recently it has looked into the matter of specifications for ordinary glass-ware and has found that the need for reliable specifications in this field is just as great as in the more scientific lines. In cooperation with other government departments and the industries samples of commercial glass-ware are being obtained as well as copies of specifications, where these exist. The Bureau will examine the samples, correlate the specifications and endeavor to formulate more satisfactory ones, based on this work.

STRATIFIED SOAP FILMS AND MOLECULAR REALITY

THE properties of stratified soap films are a very striking evidence of the real existence of molecules. In the research at Paris under Professor Perrin, the black spot was shown to consist of oleic acid just two molecules thick. The thicker strata are simply superposed bimolecular layers. Results of this work were presented before the British Association at Cardiff in August, 1920, to the American Physical Society at Washington in April, 1921, and before the Physics Conference of the Massachusetts Institute of Technology at Cambridge, in May, 1921. The properties of very thin films form a fundamental part of the study of the structure of foams, jellies and similar colloids.

INVESTIGATION OF RUBBER JAR RINGS

IN the preservation of foods in glass jars, the quality of the rubber rings used to obtain an air tight joint between the jar and cover, plays an important part. For some time, in cooperation with the Bureau of Home Economics of the Department of Agriculture, the Bureau has been investigating the properties of the rings on the market, and a specification was prepared which would aid purchasers in buying only suitable rings. Recently it was decided to supplement the laboratory tests with actual canning tests to be conducted under the supervision of the Department of Agriculture. The results of the experimental work of the Bureau and the actual service tests will then be correlated and possibly a revised and improved specification will be issued.

TEMPERING OF HARDENED STEELS

AN investigation of this subject, now in progress at the Bureau, has for its object the demonstration of the structural changes which occur in hardened steels upon tempering. The work has now progressed sufficiently far to show that there is a decided change (best seen in high-carbon steels) brought about by tempering at approximately 240° C. Up to that temperature no structural change is to be seen. In all cases the changes which occur are relatively inconspicuous and this accounts for the surprising lack of data of this kind in the literature, although an immense amount of work has been done upon the subject of hardened and tempered steels.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Socitey of Mechanical Engineers

ALLOYS OF TELLURIUM WITH SOME WHITE METALS

By J. H. Ransom and C. O. Thieme

The experiments carried out covered alloys of tellurium with 50-50 tin-lead solder, with lead, tin, zinc, aluminum and zinc-base die-casting metal.

Tellurium was added to the molten metals in comparatively small percentages. When it was added to the solder it burst into a glow and then seemed to form hard lumps which only slowly and in part disappeared. No samples of these lumps have been secured for analysis.

As regards the results obtained, it was found that in some cases the addition of tellurium reduced the amount of copper in the solder. No appreciable difference was found as being due to the addition of tellurium to lead and tin, but in the case of aluminum the tensile strength increased from 13,940 to 14,810 pounds and the elongation from 18.5 per cent to 28.5 per cent. In the case of zinc, no difference in elongation was found, but the tensile strength increased from 4955 pounds to 5510 pounds per square inch. On the whole, it would appear that where metal dissolves tellurium the hardness and tensile strength are increased to an appreciable extent. In all cases investigated it is probably that tellurides of the metals are formed and that these are little soluble in the molten mass.—*Chemical and Metallurgical Engineering*, Vol. 25, No. 3, July 20, 1921, pp. 102-103.

THE MANUFACTURE OF CHARCOAL IRON BOILER TUBES

Description of the processes employed by the Parkesburg Iron Co., Parkesburg, Pa. The processes of interest, partly because of the considerable use of this kind of tubes and also because of the fact that the manufacture of these tubes has been to an unusually slight degree affected by the general processes of mechanization of modern industry.

The first stage in manufacture is selection of scrap to go into the melt. Metal containing copper, tin, nickel, chromium or more than one-half of one per cent silicon is considered to be unfit for use as these elements tend to make the finished product dry or brittle and unweldable.

The charges, in not more than 300-pound lots, are placed in small forge fires in furnaces which to all intents and purposes have not changed in the last thousand years. In a rectangular hearth about 16 inches deep by 2 feet square with a cast iron box about 3 feet high and open in the front, the charges are slowly melted in incandescent charcoal, the required oxygen being furnished by a blast of air entering the charcoal bed at about half its depth. Under the action of the blast the light scrap begins to melt and during the heating the impurities such as carbon, manganese, silicon and sulfur are slowly oxidized, a relatively large proportion of iron also undergoing the same process. The oxides unite to form a high basic slag with a comparatively low melting point and therefore quite fluid.

Gradually the mass becomes a conglomeration of microscopic grains of pure plastic iron, each covered or glazed with a film of slag.

The incandescent lump is then removed to a steam hammer where it is forged or "shingled" to a bloom about 30 inches by 5 inches by 6 inches. Before it is placed under the hammer the lump resembles a sponge with the holes filled with the molten slag and the whole covered with a husk of iron oxide and partially consumed charcoal. Under the hammer most of the slag between the grains of the iron is forced out. From the hammers the hot blooms are passed to a reheating furnace and then rolled into bars. In this process the balance of the slag is almost entirely worked out.

After cooling, the bars are sheared into the required length, reheated and re-rolled, in a two-high plate mill. The rolling is done transversely, that is, the length of the pile is parallel with the axis of the rolls. The pile is run through the mill until the length of the resulting slab is equal to the desired width of the finished plate. The slab is then turned through 90 degrees and rolled for length and thickness to give the iron cross fiber or additional strength across the grain. The metal is always rolled in the same direction and it is plain that by this method the few impurities left are worked to one end of the plate which is dropped off and a much better surface is obtained.

The plates are next trimmed into strips of the proper width to make the tubes ("skelp").

The rest of the operations do not materially differ from the manufacture of welded tubing or other kinds.—*The Boiler Maker*, Vol. 21, No. 7, July, 1921, pp. 187-190 and 212.

THE CARBONIZATION OF LUBRICATING OILS IN INTERNAL-COMBUSTION ENGINES

By Frederic H. Garner

The paper discusses the factors which cause decomposition of the oil in the engine, decomposition being considered the fundamental cause of carbonization. According to the opinion of the author, decomposition of oil in an engine can occur in two ways, namely:

First, rapid carbonization due to exposure of the oil in the form of a fine spray or mist to the explosion flame causing incomplete combustion of the oil; the result of such carbonization is the production of carbon and asphaltic material.

Second, gradual carbonization of the thin oil film on the piston and cylinder heads at temperatures of 200 to 400 degrees Cent. giving first asphaltic material which is changed to carbon by the prolonged action of these temperatures.

The paper describes experiments to determine the evaporation losses and degree of carbonization for various oils and the estimation of the asphalt resin content of lubricating oils.

Among other things it was found that the evaporation losses of lubricating oils of similar boiling point range were approximately the same whether the oils were derived from Texas or Pennsylvania crude.

It was also found that for similar oils there is a general relationship and that the higher the flash point of the oil the lower is the amount of asphaltenes formed in a given time at a given temperature. Moreover, the rate of asphaltene formation appears to follow a mathematical law and decreases almost uniformly with rise in flash point and fire point of the oil. Direct carbonization increases much more rapdly than the evaporation loss, both as regards increase of time at a particular temperature and increase of temperature after heating for the same length of time.—*Journal of the Institution of Petroleum Technologists*, Vol. 7, No. 26, April, 1921, pp. 98-126.

PHANTOM WHEEL GRINDERS

Description of the new type of grinders of American manufacture. The device was invented in the first place for grinding extremely thin pieces of hardened steel. The pieces are not absolutely flat when they come from the hardening process to the grinding operation and would not lie still under

the wheel unless packed. Packing each piece to grind first one side and then the other alternately would render the cost prohibitive, even if it were possible mechanically. A magnetic chuck could not be used because some of the pieces were so thin that even the pull exerted by each would distort them. To handle these wheels a special bearing was provided of such character, however, that there was no very efficient way of conducting the heat away from the piece being ground. Furthermore, a solid wheel wide enough to cover the surface of the work would quickly sweep the pieces off the chuck or would overheat them and a very narrow wheel that would enable the operator to avoid both these troubles would take a long time to traverse over the width of the piece, besides being likely to induce distortion because of the slow progression of the hot spot across the work.

It was to avoid these troubles that the phantom wheel was developed.

The parts of the phantom wheel are shown in Fig. 2. A standard grinding wheel 7 inches in diameter and about ½ inch width of face was first mounted in the usual manner and dressed to the shape shown in the figure, leaving a very narrow face. A sleeve was then fitted with a pair of collars, one face of each collar being machined to form an angle of about 15 degrees with its axis.

These collars are keyed to the sleeve. The lead bushing of the grinding wheel is then dug out to allow the wheel to tilt to an angle corresponding to that of the collars, a ring nut holding the whole combination together.

When the whole combination is first mounted on the grinding machine the periphery of the wheel does not run through. There are two high and two low spots. In other words, the wheel, though round of itself, will appear to be elliptical. To correct this condition the periphery must be redressed and thereafter the ring nut that binds the parts together must not be slackened, for the wheel that now presents a truly circular periphery to the work is in fact elliptic, as may be seen in Fig. 4, and as is shown by the calipers, the actual difference between the larger and smaller diameter with a wheel initially 7 inches amounts to about 3/32 inches.

The grinding action of the wheel is effectually the same as that of a solid wheel of the width equal to the scope of gyration, but the action may be represented as a series of contacts progressing back and forth across the work in a direction at right angles to its lineal advance.

When in motion, the solid lines of the wheel disappear and though the wheel is grinding with the apparent continuity of a solid wheel of 1 inch face and throwing sparks clear across the work, the work is at no time concealed from the operator's view.

Furthermore, because of the narrow surface in contact with the work at any time, comparatively little heat is generated and it becomes possible to cover the entire surface of the work without side traverse and with little danger of drawing the temper.

The original article shows a rather unusual method of dressing the wheel in which the diamond is placed at an angle of 45 degrees.—*American Machinist*, Vol. 55, No. 2, July 14, 1921, pp. 44-45.

REMOVING SCALE FROM SURFACE CONDENSER TUBES WITH HYDROCHLORIC ACID

By Norman G. Hardy

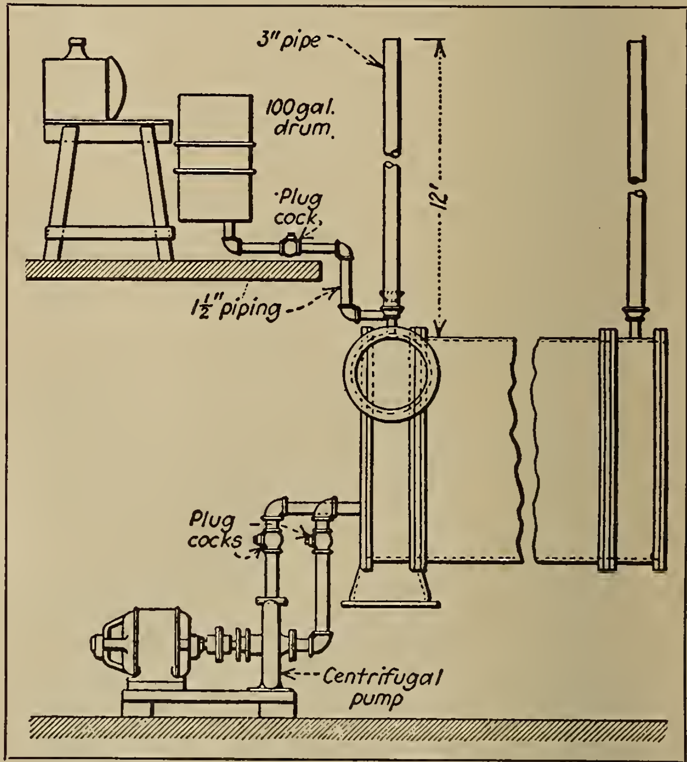
Data obtained from the practice of the Arizona Copper Co. at Clifton, Ariz., where hydrochloric acid has been used to clean condensers for the last two years. It is not claimed that this method is entirely satisfactory or that it is suitable under all conditions, but it has given very good success at the plant.

The general arrangement of apparatus is shown diagrammatically in the figure. The condensers in this outfit have a tube area of 7600 square feet in 2500 Muntz metal tubes ¾ inch in diameter by 15 feet 1 inch long. The condensers have two passes with a vertical diaphragm between water inlet and outlet compartments.

Before using the acid, both heads are removed from the water boxes, the tubes are washed out with a hose, the scale is cleaned from the water boxes, the heads, and so far as practicable, from the tube sheets also; after drying thoroughly, water boxes, heads and tube sheets are painted with two coats of roofing cement, to eliminate all chances of corrosion of the permanent parts of the condenser.

At first an acid-proof paint was tried, with the idea of maintaining a coating that would only have to be replaced occasionally, but it was found that the coating would not remain serviceable from one cleaning to the next. After trying several asphaltic paints, it was decided that roofing cement, such as is ordinarily supplied for cementing the seams of prepared roofing, was best because it is sufficiently acid resistant, can be easily applied and dries quickly.

Cover plates with gaskets are next fastened over water inlet and outlet with capscrews tapped into the water box. The heads are then replaced and the apparatus connected up as indicated in the figure. Vent pipes about 12 feet long are placed at the top of each water compartment. The water



ARRANGEMENT OF APPARATUS FOR CLEANING CONDENSER WITH HYDROCHLORIC ACID

boxes are tapped for 1½-inch pipe and have a short nipple and reducer to connect to the 3-inch vent pipe. These vent pipes are very necessary, and it has been found that gas will blow water over if a height of less than 12 feet is used. To circulate the solution a 2-inch brass centrifugal pump with direct-connected motor drive is used.

The acid used is commercial hydrochloric, averaging about 24 per cent HCl. It is estimated that the water boxes and tubes will hold 7800 pounds of water and 1000 pounds of acid is used for cleaning, making the solution about 3 per cent HCl. A stream from a ¾-inch hose is used for supplying water and the time required to discharge a measured quantity to the mixing tank is noted. From this the length of time necessary to empty one carboy of acid, with water flowing into the tank continuously is calculated. Having the outlet from the mixing tank open, the water from the hose and the acid from the carboy are delivered into the mixing tank at a predetermined rate, whence they flow into the condenser continuously until it is filled. This is a rather crude method of

proportioning the mixture, but it has been satisfactory in practice.

As soon as the level of the solution in the condenser rises above the pump suction, the pump is started. It is kept running for four to five hours, by which time the acid is entirely neutralized. The solution is usually not drained from the condenser until the following day.

The amount of scale actually dissolved is relatively small, being equivalent to a thickness of about 0.001 inch for the condenser and mixture described. But the great benefit of acid treatment is that it softens and loosens scale, so that it can easily be removed by washing and brushing. For this reason, if the condenser is very dirty, it will probably be more economical to treat it several times with a weak solution, washing out the loosened material between treatments, than to use a stronger solution.

The principal objections to the use of acid for cleaning are high cost and the possibility of injury to tubes and packing. The first of these is undoubtedly justified and eliminates this method in any case where the tubes are in good condition and the scale not too hard to permit mechanical cleaning.

With regard to the second objection, it can be positively stated that the experience of the Arizona Power Co., Ltd., for two years past does not indicate any serious deterioration of tubes as a result of the use of acid for cleaning.—*Power*, Vol. 54, No. 1, July 5, 1921, pp. 22-24.

PIPE LINE TRANSPORTATION OF HOT OIL

By Leonard L. Barrett

Discussion of effect of applying insulating coverings to hot oil pipe lines such as are found in the Californian, Texas and Mexican fields with special reference to the economic results to be obtained by such practice.

The rate of heat lost from a hot oil pipe line has a governing effect upon the location of stations. As the temperature of the oil drops, due to loss of heat by radiation, the viscosity of the oil increases rapidly and a point is reached where it becomes necessary to install a pumping station and heaters to force the oil along. The low specific heat of crude oil (approximately 0.5) accounts in a measure for the rapidity with which the oil drops in temperature during its passage through the pipe line, because for a given loss of heat the temperature of the oil will drop twice as fast as would that of water.

The chief advantage of a suitable insulating covering in the pipe line is found in the heat saving which is effected as it permits to space further apart the pumping and heating stations which form the principal element of cost in pipe line construction. It is stated in this connection that the loss of heat to the air from a pipe covered with a 1-inch thickness of 85 per cent magnesia is 0.45 B.t.u. per square foot of pipe surface per hour per degree temperature difference, while the loss of bare pipe is between 4 and 5 times as much and the ditched pipe may even exceed that of pipe in air if the ground is wet.

An extensive calculation of the flow of viscous fluids, of spacing of pumping stations and temperature of oil during flow is presented. This is accompanied by temperature distance curves, viscosity distance curves, density distance curves and calculation of thermal efficiencies obtained in practice.

As regards the coefficient of radiation, it is stated that the values given in the article for above-ground insulating lines are very reliable, likewise the values for above-ground and uninsulating lines though the latter have been determined only for still air conditions and would have to be increased for air in motion. The value of the coefficient for ditched uninsulating and insulated cannot be considered as fully reliable.

The discussion of the economic aspects of the question brings the author to the conclusion that insulation of pipe lines would bring the following net savings (based on present cost): A capital saving of \$72,000 per 100 miles, an annual saving of \$36,700 per 100 miles and a saving of 3.85 per cent per 1000 barrel-mile cost. To this is to be added the advantage gained through the protection of the pipe from electrolysis and the steadiness in operating conditions which is gained by eliminating all the trouble due to moist ground during rainy weather.—*Chemical and Metallurgical Engineering*, Vol. 24, No. 26.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

VOLTAGE REGULATION AND INSULATION FOR LARGE POWER, LONG DISTANCE TRANSMISSION SYSTEMS

Heretofore the distance to which power could be transmitted has been limited. The limitation is now removed by a simple method of loading the line with synchronous condensers, so that the current and voltage may be kept practically in phase. High power factor and hence high efficiency result, and the voltage rises of the system are very much reduced, thus reducing insulation strains.

A standard frequency of 60 cycles is advocated for the national system, and 220,000 volts is proposed as standard for extra large-power long-distance transmission. The system of regulation proposed will result in practically constant voltage at all points of the line at all loads. And power may be taken from or supplied to the line at any point, and the power over sections of the line or over the entire line may be reversed and the constant voltage system maintained.

A simple diagram is given, and this shows that for a 60-cycle, 220,000-volt line, the line-charging current supplies about two-thirds of the capacity current required for about 0.8 load or 320 amperes load current, and that for larger loads the synchronous condensers supply leading and for smaller loads lagging current. Thus it is seen that the transmission line has largely inherently the currents required for self-regulation, if we correct initially the power factor of the loads to near unity. Every induction motor added to the power system calls for a certain capacity current for correction of power factor to reduce the losses from motor through to the power station. Every synchronous motor added, instead of an induction motor, helps in the economy all along the line, improves the service and reduces the menace resulting from the large lagging currents. Every synchronous motor added becomes an asset to the entire system. Power factor correction should be done largely at load centers, the final correction and regulation being accomplished by the transmission line capacity current and the synchronous condensers.

The advantages of such a system are: Simpler and cheaper generators, transformers standardized for one voltage, insulation strains are reduced and a safer system results, and with constant voltage the flow of power has the greatest possible flexibility. This will give a system power transmission comparable to railway transportation, with a flexibility not possible in the ordinary system which does not have the constant voltage feature.

The problems of the line insulation are discussed, and especial attention is called to the necessity for low air and leakage resistance stresses. The leakage resistance stresses are most

important. For best results these should be distributed as uniformly as possible over the insulator surfaces, under the worst conditions. Results of a large number of tests are given. A new diagram is given which results from analysis of experimental data, from which the characteristics of insulator strings may be calculated. The wet and dry arc-over may be controlled if desired, as shown by the illustrations, but it is believed best to strive for the elimination of arcs, except for cases of accident.

While the present insulators with some form of shielding or grading (and with a system of regulation as outlined by the author) will no doubt give more satisfactory results for 220,000 volts than is now obtained on lower voltage lines, it is desirable that further work be done with a view to crystallizing the best method of handling the line insulation. There is here an opportunity for some pioneer work, which will give us all that is desired, resulting in a high factor of safety for the line insulation.—Frank G. Baum. *Journal of the American Institute of Electrical Engineers*, August, 1921, pp. 643-665.

INDUCTION DISK PHONOGRAPH MOTORS

Several makes of small commutator-type motors have been placed on the market for driving phonographs. Virtually all of these motors are arranged to operate in a vertical position and drive the phonograph disk by friction through a small pulley mounted on the lower end of the motor shaft and bearing against the outer edge of the disk. The motor described in this paper is an entirely different form and is claimed to approach the ideal more closely than any other electric motor for phonograph work. It consists of four essential parts: The stator magnetic circuit, energizing coil, phase-splitting parts and the disk rotor of nonmagnetic material. The first three generate a shifting magnetic field which produces a torque in the fourth. Motors of this type have been used for many years in watt-hour meters where accuracy is essential.

The author gives a torque speed curve; it is a straight line starting at maximum torque at standstill and finishing at zero torque at maximum speed. The maximum speed is determined by the ratio of torque to electromagnetic damping. The no-load speed is generally low, seldom over 300 r.p.m. The speed under load is determined by the amount of torque necessary; the greater the load the lower the speed. As to power, it is essentially a small power-motor on account of its low speed and poor efficiency. The power is always a maximum at half of the free speed and is of course zero at standstill and at maximum speed. Since it is an induction motor it is directly affected by a change in frequency. A given motor may be operated over a wide range of frequency.

The rotor is mounted on the main vertical shaft, the upper end of which supports the turntable carrying the record. This rotor consists of a ring of copper of about 9 inches outside diameter and is supported on a light aluminum spider. The ring is about 1.5 inches wide and revolves through a shafting field produced by field coils similar to those of the ordinary watt-hour meter. Thus, all gearing has been eliminated. A governor of the conventional type is used; it is geared to the main shaft by a silent worm wheel. Owing to the shape of the speed-torque curve, very close speed regulation is possible. Considerable difficulty was experienced in eliminating the magnetic hum, due to the 60-cycle circuit. This was finally accomplished by a proper design of the supporting brackets and spider, as well as by the elimination of vibration in the motor board itself. It was found that an aluminum spider was very much quieter than a cast iron spider when supporting the same weight of disk. The motor board is suspended by three screws, which are surrounded by sponge rubber bushings and washers.

The advantages claimed for this motor are: (1) Extreme simplicity and absence of sliding contacts. (2) Very small power absorbed in bearing friction and extremely long life. (3) The motor has been built and attached to the board as a unit, making it completely interchangeable with the spring motor, and weighs ony 7.69 pounds as against 10.88 pounds for the spring motor. (4) No damage can happen to the rotor or windings or increase in watt loss result, from stalling the motor under full voltage so that the ordinary type of friction brake may be used.—C. I. Hall. *General Electric Review*, March, 1921.

SLAG CEMENT MANUFACTURE IN ELECTRIC FURNACES

The proposal for heating cement furnaces electrically is not new; and if it were simply a question of heat energy the electric kiln would hardly be in a preferential position. Any development will depend upon the combination of two industries, the cement industry and the metallurgical industry, by making cement on the spot where the raw materials of modern cement, slag and limestone are both available. If the metallurgist can himself make something as cement out of his slag, instead of sending his slag to the cement manufacturer, a process not looking very tempting in itself may assume a very different aspect.

Experiments of this nature have for some time been going on in the Domnarfvets Jernverk of the Stora Kopparbergs Bergslags Aktiebolag in Sweden, and the originator of the process is Mr. K. G. Wennerström, of Oxlösund. Slag, mixed if necessary with limestone or lime, is melted in a cylindrical furnace, lined inside with carbon or graphite. The massive electrode is centrally suspended in the furnace, the dimensions being so chosen that the electric resistance between the electrode and the bottom of the furnace is smaller than the resistance radially between the electrode and the furnace walls. Under those conditions the heat will chiefly be generated below the electrode, and a useful circulation will be set up. With other resistance relations the surface might be overheated. The process has to be conducted so that no electric arc is formed and the production of calcium carbide is avoided. So far the runs at Domnarfvet have been made with cold slag, *i.e.*, not with the hot liquid slag. If the slag could be charged liquid into the furnace, there to be mixed with lime and to be heated until the mixture has become homogeneous the process would be cheaper and certain difficulties would be overcome. But others would arise which are now being investigated.

The 3-ton electric furnace at Domnarfvet has a diameter of 7.25 feet and a height of 5 feet. Alternating currents of 700 kilowatts at 60 volts are introduced through one massive electrode, which has a diameter of 27.5 inches. A run takes about 10 hours. When it is finished the fused clinker of cement is tapped off and a new charge of slag and lime is added. The molten mass is not completely discharged, and the electrode is kept immersed in the liquid mass. The discharged mass is tapped into wagons and spread on a grating. When it contains much lime it crumbles into a fine flour on exposure to the air; a lump of the size of a fist will do so almost at once, luminescence and heat liberation being observed during the disintegration. Some of the fine powder does not require any grinding, bigger particles are taken to the mill. When the mass is run into water and granulated, grinding is easier than with ordinary heating in tubular kilns.

The use of the electric furnace makes it possible to prepare highly-calcareous cements subsequently to be blended with other products. The power consumption depends upon the composition of the slag and the quality of the lime, as well as upon the slag temperature. Starting from the cold slag the current consumption is high—1200 kilowatts per ton of cement, with hot slag that figure would go down to half its value. The electrode consumption is about 10 mm. of electrode length per run; the thickness of the electrode is also reduced. Slags from alloy furnaces have been utilized in addition to blast-furnace slags. The slag from ferro-manganese furnaces may contain 10 per cent of manganese and iron, the latter being mechanically carried rather than chemically bound, the metal collects at the bottom of the cement furnace and is tapped off separately. Granulated slag is put in the cement furnace.—*Engineering* (London), July 15, 1921.

ELECTRIC DRIVING IN THE PAPER MILL ON HEAT ECONOMY LINES

THIS is an extensive paper contributed by Mr. A. B. Mallinson to the *Journal of the Institution of Electrical Engineers* for April, 1921.

The various uses for which steam is required in paper manufacture are first discussed. Then follow particulars of the various classes of machinery to be driven, and comments on the selection of suitable electrical gear. The heating requirements for heat economy, and the various types of power plant by which this can be attained are discussed in detail, together with recommendations on how each type of plant will be used for the different types of paper mills. The utilization of existing prime movers on "heat economy lines" is specially shown.

Next, the author takes up the factors governing the choice of electric supply and, finally, the driving of the variable-speed end of the paper machine proper is discussed in detail. The requirements for a successful drive are first enumerated, then various means of attaining that drive, not only with a single motor, but alternately with several motors are thoroughly canvassed.

The author's opinion is that electrification of existing machines will generally be on the single-motor system, as unless the gear at the back of the machine is worn out the expense of the multi-motor system cannot be justified.

For new machines, however, the multi-motor system has the following good points: (1) The cost of machine and drive is little, if any, more costly, no gearing being required. (2) With the extra-high-speed news machines now being developed, the gearing is getting almost beyond practical limits. (3) By cutting out the gearing, a narrower machine-house will suffice, thus making a marked saving in building and foundation costs. (4) When considering the installation of a new machine to replace an existing one, the multi-motor system will enable a wider machine (with consequent increased production to be placed in the same machine house, due to the reduced space required for the drive).

STREET LIGHTING

THE art of street illumination has considerably advanced during the last decade, its present state of development in this country is well described in a series of articles in the *General Electric Review* for August, 1921, which is a special street lighting issue.

Dr. Elihu Thomson writes on the evolution in street lighting. Probably no one is better fitted than Dr. Thomson to narrate the early history of street lighting. In his article, he first describes the conditions which existed during the successive periods when the fire brand, candle, oil lamp, and gas lamp were in turn the source of street illumination, and then reviews the various features in the development of the modern electrical system.

Dr. Louis Bell contributes a short article on the principles which govern the design and layout of street lighting systems. He divides installations into three classes: The first, important streets where the public congregates and traffic is congested; the second, thoroughfares which are of secondary importance; and third, residential streets and highways where traffic is light and police protection less essential. For each of these he names the amount and other requirements of the illumination, describes the means of securing the desired effects, and points out the fundamental faults that have prevailed.

Mr. W. D'Arcy Ryan, the intensive or super-white-way lighting. The first installation of this system of intensive lighting was made in October, 1916, in San Francisco, on Market Street. In less than five years the system has proved itself so attractive from the architectural, business building and protective standpoints that it has already been adopted by a number of other cities, and the idea is spreading rapidly. Mr. Ryan, who has always been an advocate of better lighted streets, presents in this article salient information as to the super-white-way system and the several existing installations.

Mr. A. F. Dickinson reviews the street lighting expenditures. Per capita expenditures in practically all municipal departments have greatly increased during the past decade. One exception has been street lighting. Ever-increasing traffic and the popularity of night recreation have so congested the streets of our cities that greatly-increased illumination has become a necessity. The author analyzes the division of the tax "dollar" and points out the fairness and economy of the assignment of a larger proportion of it to street lighting. By charts and tables he also presents per capita expenditures for street lighting by cities and by states so that one may locate at a glance sections of the country that are deficient or progressive in this respect.

Numerous other articles cover well the field of the street lighting distribution systems of the various fixtures and equipment. A reference list to street lighting literature for the period 1915-1921, contributed by the Main Library of the General Electric Co., concludes the issue.

TESTS OF THE EFFICIENCY OF ELECTRIC IRONS

THE irons were divided into five classes, according to the method of their construction, and the criterion adopted is the difference in temperature between the base and the upper part. The best efficiencies were obtained with the irons of class E. In these the heater is pressed against the base by a separate compression plate. Above the compression, but with an air space between there is a weight. The whole is covered by a sheet-iron cap which is thermally insulated from the base by an asbestos sheet and from the remaining parts of the iron by air insulation. In the tests the temperatures on the base and top were measured by thermo-electric couples.

The efficiency of the irons as a means of conducting heat to clothes is measured by various methods. According to one method the irons were placed on two sheets of soft asbestos moistened with water until the temperature of the latter reached 200 deg. Cent. The variation of temperature with time at the top and base of the five irons is given. Iron E heated the asbestos sheets to 200 deg. Cent. in 34 minutes, the other irons requiring from 43.5 to 49 minutes. Other methods of tests include three forms of water calorimeter.—*Elektrotechnische Zeitschrift*, January 20, 1921.

GROUND CHOKE COILS AS A PROTECTION AGAINST GROUND CURRENT AND OVERVOLTAGES

MR. R. BAUCH contributes a long theoretical treatise dealing with the action of a grounding choke coil. Without the use of such a coil a voltage of about four times the normal value has to pass through one phase of a three-phase transformer in case of a ground on one phase, which will in most cases cause a puncture. Connecting a grounding choke coil to the Y-point of the transformer will prevent the reflection back through the transformer with increased potential of a line disturbance caused by a ground on the line but will annihilate this oncoming energy and pass it to the ground. It is necessary, however, to have all this energy pass through the winding of the transformer. Its coils will not stand this stress if the overvoltage disturbance is backed by a large amount of energy. The grounding choke coil is therefore not suited for the safe annihilation of traveling waves. By means of theoretical calculations the author finds that it is much better to employ on a three-phase line three pole grounding coils instead of one Y-point choke coil. Such a pole ground should consist of a three-phase transformer with a fourth magnetic return, *i.e.*, a four-legged core. Its primary is star-connected with grounded neutral ;the secondary is an open delta, closed over a special regulating iron-core reactance. The author describes in detail laboratory experiments made with such "quenching" transformers using the oscillograph extensively to investigate its operation. Finally the actual construction of these transformers and their proper connection is given.—*Elektrotechnische Zeitschrift*, June 2 and 9, 1921.

Progress in Mining and Metallurgy

Abstracts of Recent and Coming Papers

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

ELECTRIC POWER A FACTOR IN THE ANTHRACITE FIELD

By W. A. Thomas

Steam is, and doubtless always will be, the basic power in the anthracite industry, either directly applied through engines and pumps or electrically. The rapidity with which electric power is being applied to the mining and preparation of anthracite leaves little doubt as to its utility and economy. There is practically no operation, except possibly the drilling of hard rock, that has not been successfully electrified and the matter of drilling is handled economically with electrically driven compressors and the standard compressed-air drills.

The reports available for the year 1920 indicate a production of slightly over 80,000,000 tons of anthracite, of which 8,843,500 tons were used for power and heating purposes; in other words, over 11 per cent of the production was used at the mines. Some of this was used to generate electric power at the mines, about 160,000,000 kw-hr., while 150,000,000 kw-hr. was purchased from the public utility companies.

A careful study of the field indicates that steam-operated plants use upward of 13 per cent of the production for power and heating, while electrically operated plants use about 1 per cent for heating; so that, for steam-power purposes at least 12 per cent, or 268.8 lb., are used for power out of each ton produced. Twenty kw-hr. per ton would be a conservative average value for electrified operations.

The large central station consumes from 3 to 4½ lb. of No. 3 buckwheat coal per kilowatt hour at the switchboard and 5 lb. per kilowatt hour at the mine metering point will more than cover the central-station requirement for delivered power. With 20 kw-hr. per ton, this gives us 100 lb. of fuel per ton production at electrified operations, as against 268.8 lb. per ton at steam operations; thus effecting a possible saving of 168.8 lb. per ton produced. It is assumed that 50,000,000 tons production may be practically electrified as the power becomes available with a possible saving of 3,767,000 tons of fuel, which can be released to the market.

In gaseous mines, it is not advisable to electrify the fans unless these are supplied with power from a plant on the property with reserve generator capacity or from a public utility service having two circuits to the service. This, of course, depends on the hazard involved from failure of the fan drive for short periods.

As to cost and operation before and after electrification, it is unfortunate that careful records are either not kept or are grouped with other subdivisions of production costs so that it is difficult to get many accurate comparisons of cost.

In one case complete data are available. The operation had two boiler plants, both with part of the steam driving direct-current generators and one having the usual nest of air compressors. In electrifying, it was necessary to install motor drive in the breaker and washery, replace a large breaker wash-water pumping station, build three converting substations, install several new hoists and pumps, and change the drive on steam and compressed-air hoists and pumps and fans. Separate job numbers were assigned to each installation, against which all charges were made for complete installation; on completion it was found that the total cost was not quite $125,000. This expenditure was made for an estimated saving of $44,600 per year; but before the year was up, 1917-1918, wages, fuel value, and for part of the year, power rates had advanced to such an extent that the actual saving was over $85,000 the first year.

In another case, a careful study shows that an expenditure of slightly over $900,000, not taking into account a considerable amount of good equipment that could be salvaged, would effect a possible saving in operating cost of $440,000 per year at the present public utility rates for electric power. This is typical of many cases where the gross annual saving, by complete electrification, will be at least 50 per cent of the cost of the change over and always makes possible a greater output, where this is limited by power equipment or power supply.

In this connection, it should be noted that complete electrification will show the greatest economy for the reason that, while partial electrification in many cases shows great saving, it does not reduce the total steam cost in proportion to the reduction in the steam load. The stand by losses, maintenance of plant and steam lines, and the labor in the fireroom handling of fuel and ashes, are seldom reduced in the same proportion as the load.

There is but one conclusion, and that has been reached by many producers: viz., electric power, when properly installed, is cheaper and much more flexible than steam in carrying on the mining and preparation of anthracite.

Emphasis should be placed on proper installation not only from an electrical engineering standpoint, but from a mining and preparation standpoint as well, in order to take advantage of the possible changes in the handling of the product by reason of the greater flexibility of electric power.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

GENERAL GEOLOGY OF CATORCE MINING DISTRICT

By Charles Laurence Baker

The district of Catorce, San Luis Potosi, ranks among the first half dozen silver-producing camps of Mexico. Mining has been more or less continuous there for the last 150 years. The large producing mines, Mapum, Mazapil, Palomas, Musquiz, Minas Virjas, now for the most part idle or abandoned, are grouped around the head of two valleys: one which drains to the west, falls 2000 feet in 4½ miles between the main Catorce and the western foot of the range and is characterized by steep canon walls; the other, east of the main town of Catorce, from which it is separated by a high divide, heads in a number of steep tributaries above the basin in which lies the town of Potrero, and flows nearly north for 10 miles to the northern base of the range; below Potrero it has for the most part gently sloping valley walls and a broad valley floor.

The Sierra Catorce is the highest range of the region, the summits reaching altitudes of over 11,000 feet. With the exception of a few cliffs of the erosion escarpment of the lower limestone and the canon walls below the main town of Catorce, which is the highest town in Mexico, the gently rounded slopes are characteristic of a maturely eroded mountain range composed of folded sedimentary rocks. As is usual in desert regions, the heavy-bedded limestones are the most resistant to erosive forces. Folded into anticlines, they form the mountain ranges; and the intermontane valleys and basins, originally carved out of less resistant shales, clays, marls and sandstones, are covered by debris forming a mantle with surface gradually rising upward toward the hills. In time, the debris buries in deposits formed from their own ruins, all but the highest summits of the original mountains; some of this region has already reached this stage. Most of the débris is firmly cemented by calcium carbonate (caliche). Solution of the limestone by meteoric waters afforded the supply of lime carbonate, which has been redeposited upon evaporation of the waters as a cement binding the boulders, pebbles, and finer detritus.

Metamorphic rocks are exposed in the canon from the main town of Catorce westward to near the canon's mouth. These are divided into two series. The relationship between the two is not known. The probably older series outcrops between the Purisima tunnel and the main town of Catorce. A less metamorphosed series probably forms a steeply dipping anticline with axis in the vicinity of the lower town of Catorce and outcrops between the Purisima tunnel and the exposure of the immetamorphosed sedimentaries near the mouth of the canon. The age of the metamorphics is not known; they might in part be as old as pre-Cambrian or as young as Jurassic.

Unmetamorphosed sedimentary rocks overlie the metamorphic rocks with strong angular unconformity. All the more productive ore deposits appear to be in the heavy-pedded limestone of these rocks, which is 900 to 1000 feet thick.

In general, the upper sedimentary series is folded into a rather broad dome. The strata dip westwardly from the upper town of Catorce and disappear under alluvium at the western foot of the ranges. Most of the upper town lies on a sunken block at or near the summit of the dome, the sides of the sunken block being formed by faults.

Basalt or basic andesite forms a plug about 1 mile northeast of the upper town. Porphyry dikes, probably of quartz monzonite or a related rock, cut the sedimentary series in a general north-south direction.

The primary gangue minerals are calcite, quartz, rhodochrosite, and possibly some others, including anhydrite. The primary ore minerals are mainly sulfides of iron, iron and copper, lead, zinc, arsenic, antimony and bismuth. Mercury sulfides are found south of the main district. Subsequent alteration of the sulfides formed, principally in the oxidized and leached zones, the haloid silver minerals, the double salts of silver, and possibly even more complex silver minerals.

The main deposits are fissure veins in the lower limestone. The intersections of veins were the sites of rich bonanza ore-shoots. There are also quite a number of pocket deposits, as in the other regions of limestones in northeastern Mexico.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

SLUSH PROBLEM IN ANTHRACITE PREPARATION

By JOHN GRIFFIN

IN the preparation of anthracite, the modern breaker uses approximately 1 gal. of water per minute per ton of production per day. As this water leaves the breaker it contains from 4 to 15 per cent solids, by weight, and is then known as slush. None of the solids is larger than 3/32 in. in diameter.

Slush dams afford a fairly low-cost method of retaining the solids, to prevent pollution of streams, where the slush can be run to the dam by gravity. The retained solids, however, are so mixed with limes and fireclay that they cannot be utilized for fuel without further preparation. Settling tanks of various types were developed to recover as much of the solids as possible in a relatively dry condition, so that a large tonnage could be stocked on limited areas, but during the past two years several slush-recovery plants containing Dorr thickeners and classifiers have been installed.

The first plant for recovering the granular coal was installed in 1919, at a breaker producing 5000 to 6000 tons per day; its total cost was $16,738. The slush amounts to about 4000 gal. per min., contains about 5 per cent total solids and is made through a 3/64-in. round-mesh screen. The plus 60-mesh solids form about 40 per cent of the total solids, while those between 60 and 100 mesh amount to about 20 per cent more. When the breaker shipments average 5000 tons per day, 200 dry tons of solids are recovered from the slush at a total operating cost of from 9 to 10 cents per ton.

A plant installed in 1920 is recovering the granular solids from 2200 gal. per min. of slush made through a 1/16-inch round-mesh screen. After this plant had been in operation a few weeks, the bed of the stream for several miles below the breaker had become freed from the solids deposited and after 7 months no signs of deposit were apparent in the stream. Based on breaker shipment, the cost of preventing pollution is slightly under 1 cent per ton shipped, if the recovered coal is considered of no value.

If the recoverable coal in slush is converted into domestic fuel, it will add 9 per cent to the present domestic shipments of anthracite. If it is pulverized and used in mine boiler plants, it will produce 59 per cent of the power required to operate the mines and make available for other purposes about 5,600,000 tons annually of barley and rice coal.

Complete prevention of stream pollution, except under unusual conditions, may be obtained at a cost of 1 or 2 cents per ton of breaker shipments, if no value is placed on the recovered coal. If the recoverable coal is valued at 35 cents per ton, the coal recovered will pay the cost of recovery and of preventing stream pollution by the slush solids that, at present, have no commercial value.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

POWER INSTALLATION AT COVERDALE MINE

By CHARLES M. MEANS

A THOROUGHLY modern coal handling system has been installed at the Coverdale mine of the Pittsburgh Terminal R.R. and Coal Co., about 11 miles from Pittsburgh on the Montour R.R. Power is delivered to the mine at 22,000 volts, and is stepped down by three 833-kv-a., single-phase, 60-cycle, oil-insulated, self-cooled transformers to 2300 volts.

Direct current for the mine circuits is supplied by two motor-generator sets, which are arranged to operate singly or in parallel. The main switchboard has two panels for the feeder circuits to the mine. These circuits are carried down the airshaft in rigid iron conduits, which are clamped to the concrete shaft lining. The negative lines are connected to a permanent ground underneath the substation floor.

The hoisting equipment at the air shaft consists of a Vulcan hoist, with cylindro-conical drum, with herringbone gear drive from a 250-hp., 2200-volt, induction motor with wound rotor. The control equipment is so designed that the motor cannot be accelerated beyond a fixed rate. A Webb trip recorder gives at 24-hr. record of hoisting.

The main hoist is the first Ilgner-Ward-Leonard hoisting installation in the Pittsburgh district. The main shaft is of rectangular section with semi-circular ends and is concrete lined from the landing blocks to the collar, a distance of 340 feet. It is surmounted by a steel head frame, which forms part of the tipple structure. Each of the two hoisting compartments contain a Lepley self-dumping cage designed to carry two type, the equipment being installed in a brick building of two cars side by side on a single deck. The hoist is of the end-lift rooms placed parallel with the long dimension of the shaft. One room contains the hoist, the other contains the contractor panel, flywheel motor-generator set, slip regulator, etc.

The hoist drum is of the cylindro-conical type, having two cylindrical sections 9 feet in diameter, two conical sections, and one 11 ft. cylindrical section in the middle. It is driven, through single-reduction herringbone gears, by an 850-hp., 350-r.p.m., 600-volt, shunt-wound, direct-current motor, which receives power through a flywheel motor-generator set consisting of a direct current generator, exciter, and flywheel driven by a wound-rotor induction motor connected to the 2200-volt line.

The tipple is of substantial steel and fireproof construction. When dumped, the coal passes into weigh pans, then to the shaker screens or the mine-run chutes. Circular picking tables are used instead of the straight-away type, giving a compact arrangement. As far as practicable all wiring in the tipple is enclosed in rigid iron conduit and there are no open switches for the men to handle.

AUTOMATIC SUBSTATIONS USED IN COAL MINING

By R. J. WENSLEY

THE use of small substations for the supplying of 275-volt energy to the locomotive and cutting machines in coal mines

is a well-established practice. A few years ago, when labor costs were lower, these substations were located as near to the load as possible, and an operator was provided for each station. This practice has now become so expensive that substations are being located with reference to other mining machinery, such as hoists or pumps, so that one operator can look after both; sometimes the substation is operated by one whose duties make him traverse quite a large area. In such cases the interruption of alternating-current supply may produce a long interruption in the direct current, as the station cannot resume service until the operator reaches it, and such interruptions interfere seriously with production and may easily counterbalance the supposed saving gained.

The grouping of substations for convenience in operating may also result in excessive copper loss and consequently poor trolley voltage, with its attendant evils of low locomotive speeds and increased locomotive motor maintenance. The speed of the coal-cutting machines will also be reduced. By relieving the substation of its burden of the operating labor cost, the most economical location, from an electrical standpoint, may be chosen. The matter of machine insurance should also be considered. The saving in maintenance costs is often the smallest item, when considering the automatic substation as machine insurance. When the coils in a machine are roasted out, due to continued overload or to operation under abnormal alternating-current conditions, the loss in production will easily offset the repair bill in most instances. Automatic control allows the installation of the substation above ground, when the mine is not too deep, but the location depends largely on local conditions.

The most convenient method of automatic operation is by remote control through the high-tension feeder. For the most reliable operation, it is necessary that each substation have an independent feeder. Then, the stations may be started by closing the oil switch at the point of origin of the feeder; an ammeter installed at this point will show the attendant what is happening at the substation. If to reduce the first cost it is necessary to put more than one station on one feeder, a series of time-element relays can be used to start the machines at short intervals, to avoid the surge otherwise caused by simultaneously closing the starting switches of several sets. The stations may also be started by voltage relays connected to the trolleys and shut down by under-current relays in the machine circuits. This is a more expensive method and is warranted only when the power cost is high. Time switches may be used to start the stations according to a definite schedule if desired. Control may be had from pilot wires run to convenient points where attendants are always available.

There is a feeling among coal operators that automatically controlled substations are too expensive for the average mine. This is not at all true. A 200-kw. set with 2200-volt 60-cycle synchronous motor and 275-volt direct-current generator with manual switching would sell at the present time for approximately $6150. The same machine with the simplest type of automatic control will sell for approximately $8350. This difference of $2200 capitalized at 20 per cent per year will give an annual charge of $440, which is far less than the wages of a man to operate the station for even one shift per day. If the operating labor is kept below this point by giving only occasional attention to the station, serious interruptions are invited; moreover, the automatic station does the right thing at the right time much better than could possibly be done by manual operation.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

MECHANICAL MINING OF ANTHRACITE

By Herbert D. Kynor

The term mechanical mining is used to indicate the series of operations that replaces the hand methods of mining. The paper describes the machines and the methods of using them in anthracite mining; it summarizes advantages and disadvantages of the various methods and conditions favorable and unfavorable to their operation, and gives statistics concerning these methods. It then draws the following conclusions:

1. *Value of Mechanical Mining in Thin Veins.*—In nearly every case, an economy results from the introduction of mechanical mining. Veins down to 24 inches thick may be worked economically by means of mechanical devices; whereas hand mining, with the possible exception of a few cases, cannot be economically carried on in coal as thin as this. This results in a considerable increase of workable coal areas in the northern anthracite fields, and tends to prolong the life of the industry and the conservation of natural resources.

2. *Increased Production per Miner.*—The production per certified miner from a mechanical-mining operation is from two to six times as much as from the hand-mining system; therefore, per given production, fewer miners are required. This point has particular value because the miner is a skilled or high-priced worker; also, the Pennsylvania state mining laws require that a miner must have at least two years' experience as a miner laborer before qualifying as a certified miner, which has a tendency to restrict the possible number of miners in the region. In addition, the work of the miner is less laborious when mechanical devices are used.

3. *Greater Output from Thin Veins.*—For a given area or a given amount of development, a far greater production per day is obtained from mechanical mining than from hand mining, due to the concentration of effort on a small area. This also facilitates the transportation and the incidental mine work. A steadier production is obtained from mechanical-mining units, as the coal is loaded out with few interruptions, while in hand mining a certain number of days in every period are employed in blowing and loading out or gobbing rock, which means the non-production of coal. By means of cross-over connections between gangway and airway, a number of mechanical mining units may be worked in the same section of the mine without interfering with one another, thus considerably increasing production.

4. *Greater Output per Employee.*—The output per employee for mechanical-mining operations is about 50 per cent greater in chamber work than hand chamber methods, and on longwall work as high as 300 per cent increase has been obtained. This, in itself, is a very important point in the favor of mechanical methods.

5. *Greater Prepared and Total Yields.*—Tests show that coal undercut by machine gives about 10 per cent more prepared yield than hand-mined coal. Jackhammer-mined coal blown off the solid does not give as good a prepared yield as hand-mined coal. As the speed of production is greater in the jackhammer method, the whole face is drilled at one time and fired, instead of only a few holes at a time, as in hand work. This does not permit the greatest care in the placing of holes and providing free breaking faces, as in hand mining.

6. *Percentage of Recovery.*—By mechanical-mining methods, where chamber-and-pillar work is done, the same amount of recovery can be made as in hand mining; in the longwall system of mechanical mining, 100% recovery is being made.

Generally speaking, mechanical mining has been introduced only in thin-vein work, or in thick-vein work where the physical conditions were abnormal and where it was impossible to secure men to work by the hand method. For this reason, there has been little opposition to the mechanical-mining method from the labor unions, but when the question of introducing mechanical mining into the thick seams is to be considered, as with the introduction of any machinery to replace hand work, means of controlling possible opposition on the part of the workman must be taken into consideration. If a virgin area of coal is to be worked, due consideration should be given to the introduction of mechanical methods for the entire mining of this coal, which undoubtedly under normal working conditions will result in quicker extraction, increased output per employee, and quicker returns on investment.—Abstract of paper to be presented at the Wilkes-Barre Meeting, September, 1921.

Pumping Chemicals

OUT of 465 pumps found in plants based on chemistry, 114 were Worthington, while the next make in popularity numbered only 61—a little over half the number of Worthington pumps. In other words, this shows one Worthington in every four pumps and a preference of two to one in favor of Worthington against the next in line.

These plants where the pumps were found are the kind where pumping is most difficult. Half of all the pumps were handling refinery oils—often mixed with acids, caustic solution, and various acids. Certainly this shows exacting pumping conditions.

These figures are the result of an investigation in which the Worthington Pump and Machinery Corporation took no part—in fact Worthington did not even know of the investigation until it was completed.

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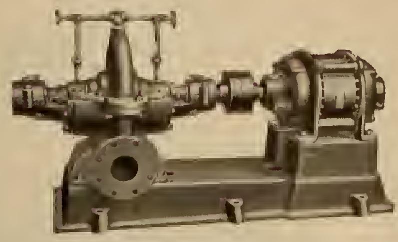
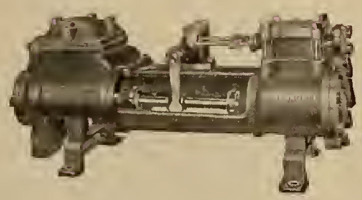
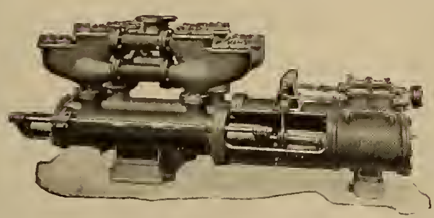


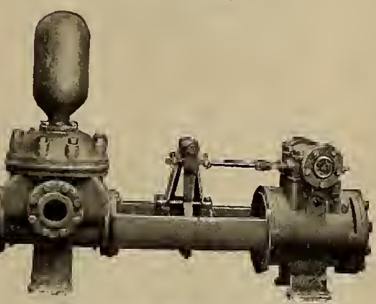
Motor Driven Double Suction Volute Centrifugal Pump



Duplex Direct Acting Piston Steam Pump



Pot Valve Duplex Direct Acting Steam Pump



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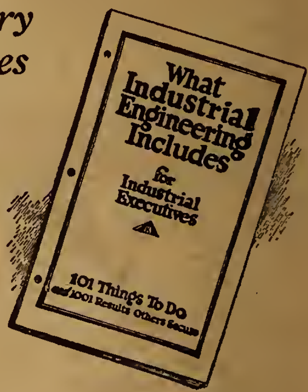

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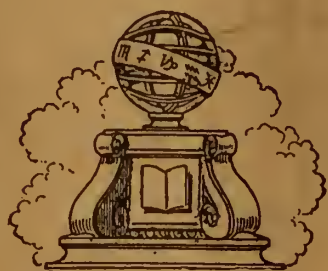

October, 1921

The Recovery of Sulfur from Blast Furnace Slag

The Art of Writing and Its Early History

The Oldest Plants in the World

Ammonia from Coal Distillation

The Ciphers of Porta and Vigenère

Industrial Applications of Ozone

Dirty Money and Disease

The Manufacture of Artificial Leather

The Behavior of Crowds

Plant Immigrants to the United States

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THE SUN GOD OF THE KATCINAS, AS HE APPEARS AT THE ANNUAL CEREMONY IN HIS HONOR (SEE PAGE 329)

SCIENTIFIC AMERICAN MONTHLY

VOLUME IV
NUMBER 4

New York, October, 1921

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Announcement

As announced in the Scientific American of September 10th, the present weekly Scientific American and the present Scientific American Monthly are to be combined into a single monthly Scientific American. The first issue of the new combined monthly publication will bear the date of November, 1921, and will appear on October 20th. Succeeding issues will be published on the 20th of each month. This change has been determined for the following reasons:

In the month of January, 1920, the weekly Scientific American Supplement, after forty-four years of publication, made its appearance as a monthly. The advantages appeared to be so many, the drawbacks so few, that the change was made with full confidence that the Scientific American Monthly would meet with approval. If letters of congratulation and increased circulation are the true test, the change has been an unqualified success.

For many months past the publishers have discussed the advisability of making a similar change in the parent publication, the Scientific American weekly. Here also the practical advantages to be gained greatly outweighed the drawbacks. Reluctance to make the change was due perhaps more to sentimental than practical considerations. We are free to confess that after bringing out the Scientific American week by week for over three-quarters of a century, we feel a twinge of real regret in making this break in the long continuity. It is done, however, for the very good reasons that, by combining the two present periodicals in a single monthly magazine, we can present the same material in a better balanced and better digested form, and at a far lower cost to the reader.

The position which the scientific weekly held seventy-five years ago, when the Scientific American was founded, is no longer a sound one. In 1845 the daily press gave the scantiest space to scientific matters. There was a real demand for a periodical devoted to the world's advance, which should not necessarily give such complete or such technical statements as the quarterlies and the annuals of the physicist, the chemist, the electrician and the engineer, but which should enable the intelligent reader to get a sufficient idea of what had been done, and to get this without waiting for the appearance of quarterly or annual.

Today this is no longer the case. The daily papers give excellent summaries of every scientific advance, of every invention of importance. As regards the mere function of a scientific newspaper, it is obvious that the weekly can compete with the daily no more than the quarterly could compete with the weekly. But the average reader is even more anxious today than he was yesterday, and similarly more competent, to know just how the new invention (which he sees announced in his daily paper) works, just what the new development in pure or applied science involves. The scientific paper that aims to tell him this, however, as explained above, can discharge the function far more effectively in the dress of a monthly than of a weekly. The same good sense that dictated the founding of the Scientific American as a weekly in order to fill the need that then existed, today demands that it be shifted into a monthly in order to do best what today it has to do.

This necessarily means that the new Scientific American will do so much of the work that has heretofore been done, first by the Scientific American Supplement and for the past twenty-two months by the organ of which this is the final issue, that the continuance of the present monthly would involve a great deal of duplication. It seems altogether best, therefore, to permit the parent publication to swallow its child.

In the matter of contents and quality we can assure the reader of the present weekly and monthly that the new magazine, which will combine the two publications, will contain within its covers the best features and the distinguishing qualities of each.

A liberal share of space will be devoted to various departments, and to a complete digest gathered from all of the technical journals, domestic and foreign, and covering the general scientific happenings of the month in a condensed and readable form. We shall continue to print the best of the learned papers, read before technical societies, such as hitherto have appeared in the Scientific American Monthly. The new monthly will have the same sized page as the present Scientific American weekly, but will contain more pages than are found in four issues of the present weekly.

In these days of heavy taxation and high cost of living the question of price takes on special importance, and here it is that the change, combining the two periodicals into one magazine, affording opportunities of enormous economies in manufacturing, mailing, and in fact, in all the mechanical labor incident to production, enables us to make a very material reduction in the cost to our readers.

The subscription price will be $4.00 a year, and 35 cents a copy on the newsstands, as compared with $6.00 a year for the present Scientific American and $7.00 a year for the present Monthly. Subscriptions to either or both the Scientific American weekly and the Scientific American Monthly, which extend beyond October, 1921, will be adjusted and extended to equalize the difference in price.

The Recovery of Sulfur from Blast-Furnace Slag

Details of the Diehl Process, Recently Brought to Success in Germany

By Paul J. Mallmann, Sc. D.

FOR many years metallurgists have attempted to utilize the heat going to waste in the blast furnace slags.

Dr. Stead, of Middlesborough, in his presidential address delivered before the English Iron and Steel Institute, in May of this year, advocated again a careful study of this perplexing problem.

Sir Lothian Bell, of Middlesborough, with his progressive associates, spent sums untold in experimental work to attain this same end.

Ledebur, Lührmann and many other German scientists exerted great ingenuity and skill to secure a practical solution.

In the early nineties, Capt. T. J. Jones, of Homestead, Pa., spent large sums of money to obtain a satisfactory result, but unfortunately the practice of waste of materials, of every description, ruthlessly indulged in, at that time, in our country, and even today not abated, created an unsurpassable barrier to the successful completion of the experiments he had initiated to convert into a tangible profit, the heat of the blast furnace slag.

A satisfactory working plant for the disulfurization of liquid blast furnace slag has been installed by Prof. Dr. L. H. Diehl, of Oberhausen, at the Guttehoffnungshütte, and credit is due to this scientist for showing us how to exploit, on a commercial basis, the waste heat of the slag.

In his report to the Committee of Blast Furnacemen of the Institute of German Iron Masters, he gives an account of the successful results of his work, and the causes that led up to it.

At the outbreak of hostilities England promptly waged war on Germany's maritime commerce, and in a comparatively short time cut off the foreign supplies of raw materials of every kind, and especially such products as tended toward the German Empire carrying on her war industries and her battles.

Now before the year 1914, Germany imported annually, from foreign lands, some 1,250,000 tons of iron pyrites, sulfur blends and other raw materials needed in the production of sulfuric acid, which commodity had created for itself a yearly demand of 550,000 tons, forming not only one of the principal corner stones on which the entire proud structure of the German chemical industry was founded, representing not only the prime factor for the recovery of soda, but being of paramount importance to the belligerents, in the prosecution of the war, since it was needed in the manufacture of explosives, of gun powder, and of other implements of destruction.

Desperate attempts were made by German chemists to harness into war service Germany's vast native deposits of gypsum and anhydrites, but the attempt failed both chemically and financially.

The history of Germany's dire straights created by this sulfur shortage will probably never be told, and credit is due to Professor Diehl for his ingenious method of solving this critical problem—by the simplest of means—by utilizing the heat going to waste in the liquid blast furnace slag, and being able to convert a practical loss into a profit, to the blast furnace plant, by recovering an average of 33 per cent of the sulfur contents up to then discarded as waste, with the slag on the dumps.

Any plant employed to exploit a process for the recovery of by-products, no matter what they are, must be low in cost of construction; the process itself must be simple and cheap; the labor bill must be low; and to justify the process and plant employed, the product must show a profit when sold.

Arguing that virtually 20,000,000 tons of slag, with an average of one and a half per cent of sulfur—representing a yearly loss of 300,000 tons of this commodity—were wasted annually on the dumps, Professor Diehl left the experiments to extract the sulfur from the existing slag deposits to a future date, and decided to make use of the relatively high temperature at which the liquid slag leaves the blast furnace to recover the sulfur contents from the slag in its flow to the waste heap.

The Diehl process for recovering the sulfur contained in the liquid slag is based firstly, on the recovery of sulfurous acid (H_2SO_3) through the oxydation of the calcium sulfide contained in the blast furnace slag by blowing air into the liquid cinders, and secondly, on introducing into the liquid bath sulfate-like anhydrites or gypsum, and a blast of air.

The chemical processes which take place when the sulfur contents of the liquid slag is oxydized through air, and through sulfate of calcium, with the help of air, are of a simple nature.

The oxygen of the air forced into the slag bath converts, *i.e.*, oxydizes the calcium of the calcium sulfide into lime, which is immediately absorbed by the meta-silicate of the slag, forming ortho-silicates and liberating free sulfur, which is burned immediately, if an excess of air is present, or is carried off, as free sulfur with the gas, if the presence of oxygen is insufficient to cause its combustion.

The following formulas give the occurrence:

$$CaS + 3O + CaSiO = Ca_2 + SiO_4 + S$$

$$S + O_2 = SO_2$$

When calcium sulfate is the oxydizing agent the chemical reaction is illustrated by the following formula:

$$CaS + 3CaSO_4 + 4CaSiO_3 = 4Ca_2\,SiO_4 + 4SO_2$$

Now it must be observed that calcium sulfide and calcium sulfate cannot exist side by side in a molten melt, an occurrence which is possible when in a solid state; in a molten silicate melt the liberated lime is immediately dissolved and the transposition between the still-present calcium sulfide and calcium sulfate continues, as is shown in above formula.

Considering the low percentage of the sulfur contents of the blast furnace slag a remelt of the cold slag was out of the question under prevailing conditions and all efforts were concentrated on recovering the sulfur from the slag in its molten state.

A series of experiments conducted over a lengthy period finally produced the plant now in operation at Oberhausen; it would go too far to describe all these investigations and tests in detail, but a brief review of the same will be found instructive.

To ascertain working conditions and how the oxygen of the air would act on the molten slag, a zinc hood through which a pipe had been passed, was partly submerged in the flowing cinders on their way to the granulating pit; through this pipe air was blown and the gases accumulating under the hood were drawn off by a gas delivery tube, and showed on analysis that they contained 23.1 vol. per cent SO_2.

This experiment was followed by passing the liquid slag through a fire-brick-lined cast-iron vat, provided with seven pipes having flattened-out nozzles through which the air was forced into the molten cinders; this vat was closed with a brick-lined hood to collect the gas. When it was found that insufficient air reached the slag to ensure the desired disulfurization and the shape of the bath appeared also to be defective, it was decided to insert cast iron channels, drilled laterally into the floor of the vat; from these holes ten pipes protruded to secure a more uniform air distribution. The results gave a gas of 9.75 per cent sulfur dioxide and 4 to 9 per cent oxygen (by volume), resultant gas well adapted for the manufacture of sulfuric acid, and other commercial commodities, but the insufficient disulfurization of the slag proved that an insufficient air volume had been introduced into the liquid cinders; this was due to the round shape of the nozzles,

and proved that the air introduced through flattened-out tuyeres gave a better result. Another useful observation was that the satisfactory progress of the process demanded a finely distributed air supply, which should pass through the highest possible layers of slag, under not too high a pressure.

Other difficulties included burning of the tuyeres, due to the fact that they were made of gas piping; the molten cinders clogging the nozzles; the clearing of the bath of the slag scales —work made difficult because the tuyeres protruded some six to ten centimeters into the vat. These were all overcome as herewith briefly described by the plant now in operation:

The construction of the bath with the permanent hood and chimneys is to be seen from drawings AB, CD, EF, GH, IJ, KL, and MN. The apparatus built into the path of the blast furnace slag run, consists of an outer structure a, a1 (through which the blast pipes k pass), supports the permanent vault b, on which is mounted the chimney c, into which the gases produced by the process pass.

The bath, or vat proper, of a total length of 3.745 meters, consists of three parts, a2, a3, and a4, cast from best foundry iron, each part of two sections, the upper and the lower, and into the upper section cooled pipes are cast, while the lower, or bottom part of the vat is channeled shaped, widening out toward the discharge end of the vat, as can be seen in drawings IJ, KL, and GH.

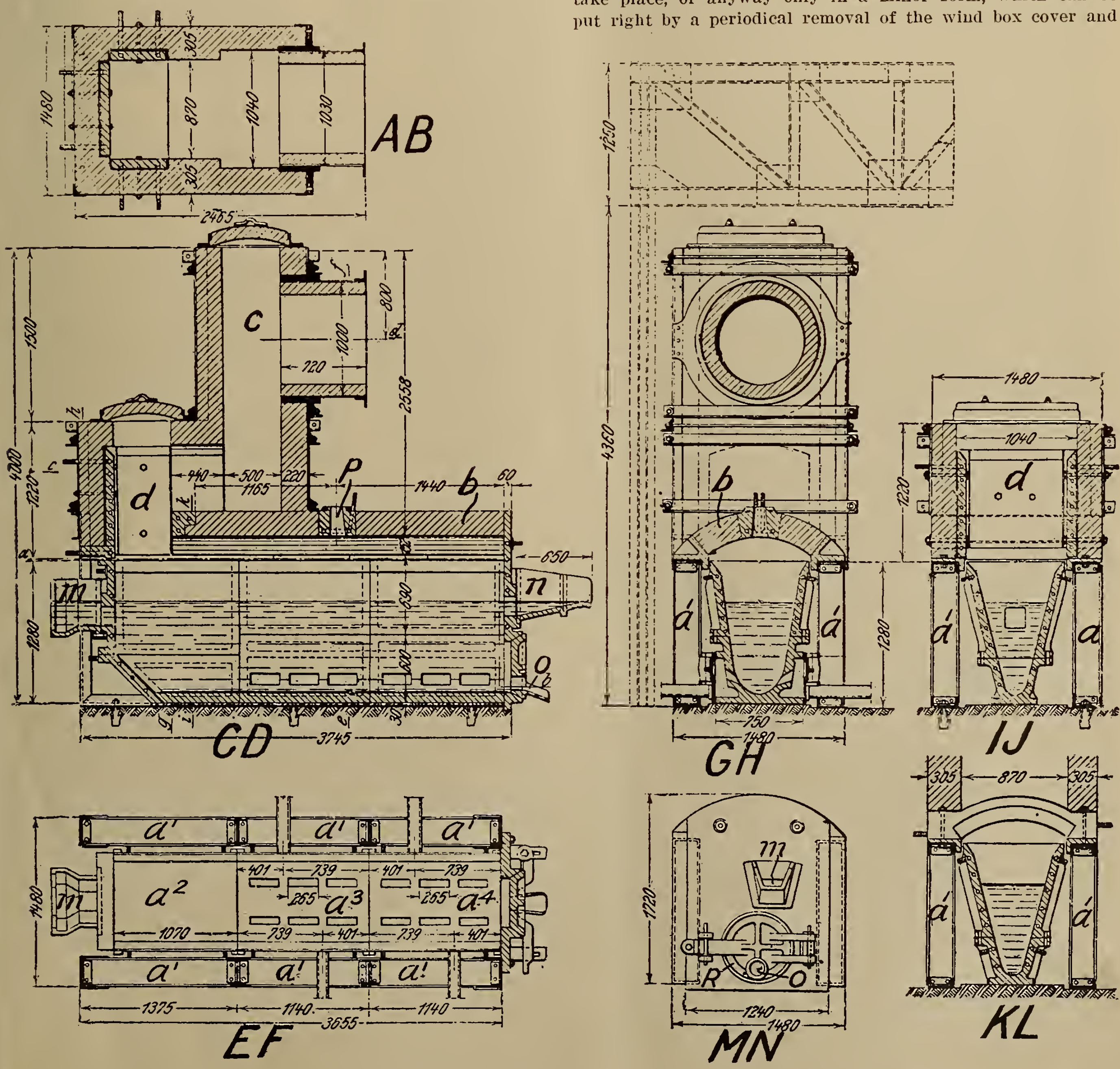
The channel-shaped sections a3 and a4 are provided with six openings each to permit the insertion of the tuyeres, as shown in drawings CD, EF and GH.

From the receiving receptacle m, the liquid slag enters the bath, the blast having been turned on in the meantime, rises in the bath till it reaches an elevation level with overflow nozzle n, and is drawn off through taphole o, on completion of disulfurization; when the bath had been emptied the door r is opened and any scales formed in front of the tuyeres removed; through the aperture p, the anhydrite additions are made.

The principal dimensions are shown in the plans of the bath which has a daily capacity of treating 180 to 240 tons of liquid slag.

OBSERVATIONS AND CONCLUSIONS ON THE WORKING OF THE PLANT

Provided that the initial air pressure is high enough and the molten slag enters the bath at such a high temperature, and at a sufficient speed, that the slag does not freeze and form a thick crust, a closing up of the air tuyeres does not take place, or anyway only in a minor form, which can be put right by a periodical removal of the wind box cover and



THE DIEHL SULFUR-RECOVERY INSTALLATION; FOR FULL DETAILS SEE TEXT

cleaning out of the slightly clogged tuyeres, an operation which does not seriously retard the operation of the process.

The apparatus must be well heated and the slag must enter the bath real hot.

The initial blast pressure must be raised from 10 centimeters mercury column to 18 centimeters, and must be retained at that pressure, unless sponge-like frozen slag scales within the bath and right in front of the mouth of the tuyeres are formed, when the pressure must be raised to 24 centimeters; this sponge-like scaly slag formation is intersected by a series of numerous fine wind channels, through which the blast passes into the liquid slag, in a finely divided spray; the flattened out slits of the tuyeres are found to remain perfectly open and free from entering slag when the previously mentioned sponge-like slag scales settle right in the beginning in front of the tuyeres, thereby protecting the tuyeres against the entry of liquid slag.

At the end of the slag run the slag scales and these previously described spongy slag formations are removed from the bath; this opens up again all the tuyeres.

The provided for, previously described permanent vault, is kept free absolutely from slag, and therefore, need not, as had been anticipated, be removed, and there is no need to provide it with an arrangement for either opening or removing the same.

The yield of sulfur is the larger, the hotter and the richer in sulfur the entering slag is, and the composition of the slag as such is also of great importance, because acid and highly soluble slag gives off sulfur more easily and more freely than pronouncedly basic slag; on the other hand the highly basic slags are, as a rule, richer in sulfur, and generally hotter, showing satisfactory disulfurization as a result.

The change in the appearance of the slag, after air treatment had taken place should be mentioned. As it is known, slags of high calcium sulfide contents are milky and cloudy in appearance, caused by the ejection of the crystalline needles formed; this is particularly the case with hematite slags.

Such milky perturbed slags become absolutely clear and glassy by the treatment under review, which proves that the procedure of disulfurization progresses as previously described, namely, that the calcium sulfide is burned and the lime thus formed is dissolved in the slag. In rare cases, particularly if the slag is very rich in sulfur, and an insufficient volume of air is introduced to assure a perfect combustion of the calcium sulfide, elementary sulfur appears and the gas obtained is poor in oxygen.

The procedure is similar to the one which takes place in the combustion of hydrogen sulfide when insufficient quantities of air have been introduced, where the oxygen of the air, the affinity of which is greater for hydrogen than for sulfur, and the affinity of which is greater for calcium than for sulfur, combines in the instances cited, with hydrogen, and in our case with calcium, freeing in the combination elementary sulfur. Though this occurrence has up to now not been utilized for the recovery of free sulfur, it still gives an explanation for the appearance of a large, long flame when air is blown through hot liquid slag, rich in sulfur, when the oxygen forces the sulfur out of the calcium combination and the sulfur so produced is carried along by the forced-in air as sulfur fumes, burning with the previously described long flame. The sulfur flame, however, is not pale blue as one should expect, but of an intensely white glare of violet shine. The glare of the flame is produced by the evaporation of the potassium hydroxide contained in the slag, which shows itself as a white fog when the gases have cooled.

When the gases are drawn off through iron pipes, the inner walls will be coated in due course, with a white salt, which consists almost exclusively of a potassium bisulfate, with a low addition of, say, 2 to 3 per cent of sodium bisulfate.

An alteration of the process consists in oxydizing the calcium sulfite of the slag in part, or in whole, by using sulfates, principally calcium sulfates, introduced at the time when the air is blown in. By doing this a very rich gas is produced, the sulfate is entirely decomposed and after this treatment there is no more sulfate of sulfur found in the slag, but only a residue of sulfur sulfides.

The temperature of the gas produced by the process is about 930 to 950 degrees Centigrade, when measured at a point situated beyond the radiation influence of the liquid slag.

Tables No. 1, 2, 3 and 4 show the results obtained with different kinds of slag.

Table No. 2a shows the average results obtained during six months' run from Thomas Pig Iron production:

Table No. 1. Air Treated Blast Furnace Slag of the Thomas Process

Condition of the Slag	Slag at Entry %S	Slag at Exit %S	Sulfur Yield in % of the Slag Weight
Good, warm	1.31	0.79	0.52
Good, warm	1.23	0.75	0.48
Long, cold	1.42	0.96	0.46
Long, slightly warmer	1.33	0.84	0.49
Good, warm	1.42	0.89	0.53
Good, warm	1.51	0.96	0.55
Cold, foaming	1.54	1.04	0.50
Cold, short	1.23	0.73	0.50
Good, long, warm	1.76	1.10	0.66
Good, warm	1.46	1.00	0.46
Good, warm	1.47	0.96	0.51
Good, warm	1.84	1.36	0.48
Good, hot	1.83	1.14	0.69
Well boiled, hot	2.03	1.25	0.78
Fairly warm, foaming	1.57	1.09	0.48
Good, warm	1.34	0.88	0.46
Good, warm	1.32	0.84	0.48

Table No. 2a shows the average results obtained during a number of months from slag produced by foundry iron production; table 2b the results obtained from hematite slags.

Table No. 2a. Air Treated Blast Furnace Slags: Origin Foundry Iron

Slag at Entry %S	Slag at Exit %S	Slag Yield in % to Slag Weight
2.35	0.97	1.38
2.21	1.15	1.06
2.35	1.34	1.01
2.44	1.26	1.18
2.44	1.19	1.25
2.45	1.20	1.25
2.40	1.15	1.25

Table No. 2b. Air Treated Blast Furnace Slags from Hematite Iron

The slag was throughout very hot; after freezing its appearance was yellow white and the segregated sulfur calcium gave it a strong cloudy, milky appearance, but by blowing air into it, it became glassy and transparent. During the blowing, flames of burning sulfur six meters long, appeared at the top of the chimney.

ANALYSIS OF THE SLAG

Slag at entry ....2.26 % S
Slag at exit ....1.03 % S
Yield of sulfur..........1.23 % S

ANALYSIS OF THE GAS

SO_2 Vol. % 10.37
CO_2 Vol. % 1.2
O_2 Vol. % 3.8
N_2 Vol. % 84.63

Table No. 3 gives the result obtained by treating Thomas slags with air, and an additional introduction of anhydrite ($CaSO_4$). The added anhydrite gives up 25 per cent of its sulfur contents in weight which naturally increases the ultimate production of sulfur.

Table No. 3. Air Treated and Anhydrite-Improved Blast Furnace Slag from the Thomas Process

The Condition of the Slag	Anhydrite Addition	Slag at Entry	Slag at Exit	S. Yield in % of the Slag Weight From the Slag alone	From Slag and Anhydrite
Good, warm	0.66	1.56	1.01	0.55	0.68
Good, warm	0.625	1.29	0.82	0.47	0.62
Short, cold	0.65	1.35	0.89	0.46	0.61
Good, long	0.40	1.66	1.10	0.56	0.66
Good, hot	0.80	2.24	1.47	0.77	0.97
Good, warm	0.75	1.83	1.25	0.58	0.76
Average	0.60	1.41	0.86	0.55	0.70
Good, hot	0.675	1.70	1.09	0.61	0.78
Well done, hot	0.60	1.70	1.03	0.67	0.82
Short, hot	1.18	1.98	1.27	0.71	1.00
Well done, warm	0.75	1.88	1.32	0.51	0.69
Long, warm	1.40	1.45	0.89	0.56	0.91

Table No. 4 shows the average sulfur contents in gas obtained from similar slag, averaging over a number of months, but without the addition of anhydrite. It will be found that the oxygen contents of the gas is quite sufficient to justify the conversion of its sulfur dioxide contents into sulfuric acid, either by the chamber or contact process.

Table No. 4. Composition of the Sulfurous Acid Gas

The gas produced from the slag contained 9½ to 10½ Vol. % oxygen.

Without Anhydrite Addition to the Slag Vol. % SO_2	With Anhydrite Addition to the Slag z z Vol. % SO_2	Without Anhydrite Addition to the Slag Vol. % SO_2	With Anhydrite Addition to the Slag Vol. % SO_2
5.70	7.27	3.60	8.46
4.93	6.34	8.19	10.34
5.11	5.63	5.77	7.76
4.50	7.57	6.11	7.66
5.63	10.85	6.51	6.37
8.09	9.95	7.10	7.17
7.58	6.81	8.39	6.37
5.03	8.19	8.96	6.86
6.20	7.78	9.85	6.97
5.92	8.88	5.57	14.11

The gas produced by the Diehl process contains an average of from 6 to 7 volume per cent of sulfur-dioxides with smaller quantities, generally speaking of 1 to 1.1 volume per cent carbonic acid, about 10 volume per cent oxygen, with the balance consisting of nitrogen. It is recognizable by the absolute absence of arsenic, chlorine, fluorine, carbon-oxide, sulfur, dust or impurities of a similar nature, but does contain small quantities of potassium bisulfate, from which it can be freed very easily. Therefore, it is preeminently suitable for the production of pure sulfur products like liquid sulfur dioxides, sulfites, particularly sodium sulfite, sodium bisulfite, calcium bisulfite liquor, sulfuric acid, and fuming sulfuric acid, produced by the contact process. In this process the stored up and up till now not utilized temperatures of the liquid slag are made use of, and at the same time the liquid silicic acid, and the liquid alumina contained in the slag are made use of to dissolve the intermediary formed sulfites and sulfates, and this is done without consuming new combustion material, which irrespective of the high cost of fuel prevalent today gives the great advantage that the obtained gas is practicably free of carbolic acid, and absolutely free of carbon oxides. Besides this, it is entirely free of the most objectionable of impurities, arsenic, because arsenic as far as it occurs in the iron ores is reduced in the blast furnace process, and enters the iron. The oxydizing blast of the air excludes almost a trace-like occurrence of arsenic in the basic slag, but should exceptionally small quantities of arsenic be found in the slag then it appears as arsenate of calcium salts.

The treatment of slag with air or anhydrite is not detrimental to the subsequent use of the slag. It can be granulated just as before treatment, and for other purposes, as for building material, etc., it becomes even better, because it is freed of its sulfur contents.

The cost of production of this gas is low, because the man attending to the slag requires one assistant only for the work of the slag bath. To this is to be added the very small expense for blast, approximately 1½ per cent of the wind consumed by the blast furnace proper; besides this, there is the repair of the bath which confines itself to the occasional replacement of a burned tuyere, and to a new pouring spout.

When anhydrite is used, the price at which it is delivered to the works has to be added, but it has to be considered that every ton of anhydrite yields one-half ton of pure sulfur dioxide, irrespective of the gas from the sulfur of the slag.

CONCLUSION

The Diehl Process answers all the conditions a by-product recovery process and plant should fulfil. It is simple and inexpensive as to the process, and it possesses the great advantage of delivering the slag in a better condition to the dumps after treatment, than before, since the slag freed of its sulfur contents makes better building material, be it cement or brick, than before.

The heat contained in the liquid slag—up to now going to waste—in conjunction with the forced introduction of air, with or without additions of anhydrites, liberates the sulfur in combination and gives the blast furnace industry a useful and paying by-product, which again does not contain many of the objectionable constituents, which render a by-product either useless or too expensive for subsequent use, and sells readily.

The plant employed is simplicity itself and may be well termed a converter ingeniously adapted for the judicious utilization of the waste heat and wasted materials of the slag up till now the cause of annoyance and worry to the iron master.

The cost of building the plant is low; operating it is cheap, because it requires actually one extra man only per shift.

Professor Diehl is to be congratulated on the ingenious and simple manner in which he has solved a vexing question satisfactorily and profitably, and our metallurgists will do well, not only in applying the lesson taught, to prevalent American practice, but also following his line of thought, attempt to solve another difficulty, namely, of profitably extracting the sulfur contents of the slag now lying in millions of tons on the waste heap.

FROSTED GLASS

In order to produce a matt surface on glass T. Ueda of Kyoto coats the glass with a substance (alkali silicate, basic lead silicate, lead salts) which when heated reacts on the glass to form a product decomposible not only by hydrofuric acid, but also by sulfuric, nitric, or hydrochloric acids. The powdered composition further contains an inert agent (powdered porcelain, stoneware, fireclay) and a binding agent (gum).

Owing to the necessity of clearing the presses for the November issue of the new Scientific American, with its much larger run than that of the present Monthly, we are forced to go to press without waiting for the usual notes detailing the month's progress in mining and engineering. We regret the absence of this feature.

Gypsum as a Building Material

The Causes of Its Failures and the Way in Which It May Be Used with Success

By Leo Griswold Hall

GYPSUM is one of our available building materials which is becoming more and more widely used, but which is as yet not very generally known, and has not consequently approached the limit of its usefulness in practice. The slowness with which it has obtained recognition as a standard construction material has also been in part due to many failures in its use in the early stages of the game. These failures were not so much due to the inability of the gypsum to lend itself to use as a dependable structural material, as to lack of care on the part of early designers, and their failure to allow for certain definite qualities in the material. Many failures naturally resulted, which have tended to give gypsum a black eye with the building trade; and many engineers, hearing of the failures, and unacquainted with the reasons for them, have simply passed gypsum by, where they could have made very substantial economies by its use. The early history of reinforced concrete is full of just such failures and prejudices. Properly used, gypsum is just as reliable as reinforced concrete—in their relative spheres.

As it comes from the mine, gypsum is a very soft grayish colored rock, with a slightly soapy feel to it. It occurs very widely in beds which vary from a few inches to several feet in thickness. It is mined in quantities in New York, Ohio, Michigan, Illinois, Kansas, Texas, California and Washington, and large deposits occur in many other states. Other varieties of the same material are known as gypsite and alabaster.

Chemically, it is a hydrated sulphate of calcium. To be made ready for use it is calcined, driving off most of the water of crystallization; an impalpable white or grayish powder resulting. This is the plaster of paris of commerce.

The calcined gypsum has a great affinity for water, combining with about 17 per cent by weight of the latter, to reenter the crystalline state, or in other words, to set. This setting takes place completely in a very few minutes—almost instantly, if there be no excess water present. It can be greatly accelerated by throwing in a handful of crystallized gypsum, to form a nucleus of crystallization. In fact in casting it is necessary to keep molds, etc., entirely cleaned after each use, to avoid setting the gypsum before there is time to work air bubbles to the surface and see that the molds are properly filled. This, together with its strong tendency to stick to everything with which it comes into contact, are the most disagreeable features of its use. This disadvantage is, however, more than made up for by the rapidity with which molds can be re-used. But I anticipate my subject.

The use of gypsum in wall plaster and moldings is so well known that I shall not go into it here. Its use in a manufactured wall board, usually rolled between heavy layers of card board is but little less known. It is manufactured in this form, I believe, by several well known companies; and when so made up, yields itself readily to any use to which wall board may be put; being readily susceptible to sawing, nailing, etc. It is a remarkably good heat insulator, and is frequently used in the walls of refrigerators, etc., more than one thickness usually being used, and protection from damp and from mechanical injury being necessary.

The use of gypsum, either cast in place, or in precast tile form as a roof or floor deck is not so well known, though this is one of the uses to which it may be put with a great deal of economy. Its high heat-insulating qualities render it a fuel economizer of no mean qualities, when used in the roof of buildings in cold climates. Its extreme lightness of weight renders worth-while economies in steel design possible when used in steel frame buildings. Its rapidity of setting, permitting forms to be removed and re-used immediately after casting, allows great economies in form materials. These, together with its high fire resistant qualities, render gypsum a very desirable structural material under the proper conditions of design, etc., for its use.

But here it is that failures have occurred, which have been due to faulty design, but which have none the less tended to give the whole gypsum slab proposition a black eye. These difficulties of design can none the less be successfully overcome; have been so in very many cases, and there are standing today very many gypsum floor and roof decks in good condition after several years' hard service. Slabs 4 inches thick over a 10-foot span are designed to hold a live load of 70 or 80 pounds per square foot, with a fair safety factor. I have myself tested a slab of 6-foot span, 3½ inches thick and 20 inches wide, entirely unfixed at the ends to destruction under a central load of 1400 pounds. This is equivalent to a uniformly distributed load of about 280 pounds per square foot. Nor was this slab specially made for test purposes. It was taken at random from a lot made for a factory roof. Others have at different times stood up in proportion. Now as to the cause of failures.

Gypsum, though it possesses some structural strength, possesses very little by comparison with cement, or any of the natural or artificial building stones. It is usually used for lightness sake mixed with chips, to give it body, but which do not add any appreciable strength to it except perhaps in sheer. Its strength in tension is at all times negligible. It has, however, in compression, a certain comparatively small but dependable strength or stiffness, *when dry.*

It is usually cast for ease of handling with a great excess of water above the minimum required for complete crystallization. When set, it is hard enough for ordinary careful handling; but the maximum strength is not attained until this surplus water is evaporated out of the mass, which may take anywhere from a few days to a few weeks, depending on the weather, conditions of exposure, etc. The drying in the case of present slabs is frequently hastened by the use of kilns.

Gypsum decks have been usually designed with reinforcing so that they are amply safe *while dry.* The reinforcing is so designed as to subject the gypsum to no tension, very little sheer, and to a certain amount of compression, which the dry gypsum is easily capable of withstanding. But what is not always taken into account is the fact that the gypsum loses the greater part of this compressive strength when wet.

Being used frequently for the roof deck of a heated building in a cold climate, without protection on the under side, there is a tendency to condense moisture on the under side of the slab. The gypsum, being very porous, and having great avidity for this moisture, absorbs it as fast as it forms, becoming itself softened thereby, frequently in long continued cold, to the point where a very ordinary load produces failure. Also, after having absorbed a considerable amount of moisture, if the building is left unheated for a while in very cold weather, the absorbed moisture may freeze, causing extensive cracking and flaking. These are the main causes of failures: witness the fact that over 90 per cent of failures are on roofs; not on floors where there is little tendency to condensation.

There are two ways to tackle this difficulty. The first is to design the reinforcing so that it will stand without depending on the gypsum except as a filler. The second is to protect the gypsum so that it cannot absorb moisture. And there is perhaps a combination of these two in the sheet metal arched cell construction of recent years so frequently used with concrete. The sheet metal domes, corrugated or otherwise deformed for strength's sake, being left in place, both

as a reinforcing to the gypsum and as a protection from moisture of condensation on the under side. I do not know of any case where this has been done, but I believe it would be highly successful without involving the use of a greater weight of metal per square foot of slab than is now commonly used under conditions of equal strength in practice.

The common method of reinforcing gypsum slab today—and the most successful one—consists in stretching cold drawn steel wire at right angles to the purlins across the deck usually consisting of several spans, and anchoring securely to a special member for the purpose at both ends. The wires are spaced variously from 1½ inches to 4 inches, depending on the designed load. In the center of each span, a transverse bar is then placed on top of the wires, being pulled down to the forms and anchored there. Under the wires and lying transversely with them on top of the purlins are small angles or bars, supported above the purlins and supporting the wires above them. The wires are under high tension and run zig-zag in a vertical plane; being in the top of the slab at the purlins and in the bottom of the slab in the center of span. The transverse bars, both top and bottom, are of sufficient size to present considerable surface to the gypsum in a vertical direction, and to minimize the possibility of their shearing up or down through the soft slab, as the wires alone would be very likely to do. The bars are usually so placed as to be about three-fourths of an inch clear of the surfaces of the slab for fire protection.

As the wires run continuously through the deck, and are tied securely at the ends, there is no way in which this form of slab can easily fail, so long as sufficient area of steel is present to prevent sheering through, and so long as there is sufficient area on top of the purlins to prevent failure by direct compression of the gypsum between the top bar and the purlin. Under proper design, this is not liable to occur even while there is no excessive width on top of the purlin.

I have knowledge of some thirty or forty factory roofs whereon this type of construction has been used; and of these, but one has been a failure. This was a case where a great deal of steam was used in the building, softening the gypsum to an unusual extent, while insufficient bearing area to allow for such softening was provided on the purlins.

Gypsum as usually cast with wood chips is very elastic, and lends itself readily to a system of reinforcing which is itself so elastic that I have tested a 3-inch slab of 6-foot span to the point where it sagged 2 inches in the center of span under load, and instantly recovered when the load was removed. The grip of the gypsum on the wires (in this case 3-16-inch cold drawn) is shown by the fact that these did not slip through the gypsum though they were not fastened at the ends. The slab which I mentioned in the early part of this article as having been tested to destruction, failed by slipping off the wires, which were not fastened at their ends. In practice the entire reliance is placed on the tying of the wires at the ends; the grip of the gypsum on the wires being simply an added safety factor, which largely diminishes when the slab is wet.

As I have said above the weakest point of this design lies in the possibility of the gypsum crushing between the purlin and the top bar. This is in some cases obviated by the use of wide bearing plates on top of the purlins and under the slab. This, of course, adds expense. I shall have more to say about overcoming this weakness later.

There are a number of types of precast tile on the market which are intended to be used in place of the deck cast in place. Some of these are flat and are intended to be fastened together at the joints—the reinforcement being tied, and the cracks being filled with gypsum grout, forming to all intents and purposes a single slab such as I have outlined above. Others are intended to act as individuals so far as their reinforcement goes, each tile standing by itself without connection with the next. They come in several shapes—flat, inverted U section, flat hollow, etc. It is in the independent tile that most of the failures of gypsum construction have occurred; for it is very difficult to devise a reinforcement, that is completely self-contained and which will stand without depending too much upon the varying strength of the gypsum, and which at the same time is sufficiently cheap to be profitable. So far as I am aware, this has not yet been successfully done. The inverted U type, wherein the adjacent vertical legs of two adjacent tile form together a beam, thus permitting a reduction of thickness of the slab, and a corresponding reduction of weight, seem to have the disadvantage that the thinner slab permits condensation to occur more readily. The only two cases of this type of roof I have seen failed for that reason. Of course, in the case of a floor slab where condensation is less likely to occur, this objection is largely nonactive. The hollow tile of various forms are helpful in that they tend to reduce condensation; and where that takes place, they tend to retard the spread of the moisture into that part of the tile which is under greatest strain under the usual conditions of reinforcement.

There are, of course, many types of reinforcement which can be made successful for individual tile under certain conditions, and which are cheap where the span is very short. Of these I might mention wire mesh stretched over a rectangular steel frame of nearly the size of the tile, and bedded in it. I have made and tested several of this type, and obtained very high strengths for spans up to 3 feet and thickness of 2½ inches. For spans of this length, the steel frame can be so light as to be very cheap. But the weight of the members of the frame increases more rapidly than the span, eliminating the economy of this type of reinforcement when this span is exceeded. This same objection applies to all types of reinforcement for individual and unconnected gypsum tile with which I am familiar.

If gypsum can be so used as to be kept from absorbing moisture, it may be depended on for a certain amount of structural strength of its own. This dry strength is sufficient to obviate much of the reinforcement difficulty mentioned above. But in keeping it from absorbing moisture, we run into another problem which has not, so far as I know, been solved commercially, but which must be solved before gypsum can come wholly into its own.

Many materials have been tried as damp-proofers for gypsum. Asphalt, various oils, paints and glazes, as well as waterproofed fibre sheets have been used for this purpose; but with little success. The great difficulty with all of them has been that they do not adhere permanently if at all, to the surface of the gypsum. The dry gypsum surface readily rubs off into powder, making it exceedingly difficult to obtain a permanent bond. The oils do not penetrate, so far as my experience goes, but either evaporate or flake off with the surface gypsum in a comparatively short time. Paints having water as a solvent seem to be the only ones which penetrate; but they do not waterproof. And though men interested in the problem have been experimenting for some years, the writer believes that this problem is still unsolved, at least by any process cheap enough for commercial purposes. Yet there is nothing intrinsically impossible in it. I have, after some experimental work, succeeded in transforming the surface of gypsum blocks into calcium silicate, a very hard insoluble substance, by the use of a suitable treatment. While this treatment does not close the pores, but still permits water to be absorbed, still the treated surface readily bonds with many waterproofing compounds which do fill the pores and permanently adhere. The net effect is to case harden the block. Nor does the hardened case show any tendency to break away from the body of the block.

I have immersed blocks so treated in water for several days with an absorption of less than 2 per cent. Blocks so immersed, when tested, showed the full strength of the dry block, and when broken, appeared dry clear through.

I am not yet prepared to go into details regarding this treatment. The chief obstacle to its use is its high cost, which

renders it prohibitive for use on a large scale. I am experimenting further in an attempt to get over this difficulty. I had a rather amusing experience when I found that asbestos or magnesium carbonate when used with gypsum under certain conditions caused fibri-crystalline growths to appear on the surface of the block. These proved on analysis to be epsom salts!

But the results which have been obtained are sufficiently encouraging to warrant the belief that the thing will be done commercially before long.

I have been able to vary the thickness of this case hardening up to one-half of an inch by varying the length of treatment. There is nothing in the process apart from cost of materials which would not yield itself readily to being done on a large scale in quantity production.

Of course, such an accomplishment, if it can be done sufficiently cheaply, will immediately open to gypsum a much wider field in the construction industry than it has hitherto occupied. In the first place, it will render it possible to use thinner tile for roof decks. It will make possible the simplification of the reinforcing of these tiles to some extent. It will render the use of composition or tar and gravel roofing on top of the roof deck unnecessary. In addition to making gypsum more reliable and simpler under conditions where it has hitherto been used, it will make it possible to put it to use in fields hitherto impossible—such as in building blocks exposed to the weather; walls cast in the same way as concrete walls are cast; shingles similar to asbestos shingles; outside ornamental work;—indeed, there is no reason why a whole building could not be built of gypsum.

Gypsum is one of the cheapest of materials—being far cheaper that cement or brick; and its use in fields now exclusively occupied by those materials would immediately bring down considerably the cost of building. Its extreme lightness of weight makes it possible to reduce considerably the amount of steel frame of buildings where gypsum is used. Its low heat conductivity makes gypsum roofed or walled buildings easy to heat in winter or to keep cool in summer; and renders gypsum a very good fireproofing material. The water of crystallization must be calcined away before gypsum loses its strength. With a lower heat conductivity than concrete, and a greater percentage of water, this calcination occurs in walls of equal thickness, more slowly in gypsum than in concrete, with consequent better fireproofing abilities in the former. Indeed, with proper weather proofing, gypsum should rise to a position second to none as a structural material. It can be used without waterproofing now in any place where it is not subject to weakening by the influence of moisture, or where its strength is not depended on except as a filler. But until it can be commercially waterproofed, its use is confined to such cases.

Following are a few facts relating to gypsum for those interested in its use:

(1) Gypsum is a hydrated sulphate of calcium of the formula Ca SO_4 plus $2H_2O$. It occurs in crystals. A granular form of gypsum is called alabaster. Another form containing a high percentage of impurities is called gypsite.

(2) Gypsum is difficultly soluble in hot and cold water.

(3) To be made ready for industrial use, gypsum is calcined, driving off most of the water of crystallization, and ground to a powder. On coming into contact with water again, it takes up this water of crystallization again, becoming hard, i. e., it sets. This takes place very rapidly.

In general, the higher the temperature at which it has been calcined, the less readily it sets. Gypsum calcined at over 200 degrees C. has all of the water of crystallization driven off, and recombines with water only very slowly, being consequently of no value for casting.

The probable reason for this is that gypsum needs already crystallized nuclei on which to build in setting. When all of the water of crystallization is driven off these nuclei are absent. Witness the fact that a handful of hydrated gypsum thrown into a cast very materially accelerates setting.

(4) Sodium silicate accelerates setting.

(5) Carbonate of magnesia retards setting.

(6) Gypsum with some soap solutions, forms an insoluble compound.

(7) For use as a wall plaster, gypsum is mixed with fine sand, and sometimes with fibre; being sold in this form under various trade names.

(8) —For use in tile, floors and roofs, it is mixed with sawdust or planing mill chips to give it body. This is the only filler that has proved uniformly successful. The proportions are varied slightly to suit conditions, and usually run about 2 cubic feet of chips per 100 pounds of gypsum plaster. The gypsum and plaster being mixed dry first, and the water added. Great speed is necessary in mixing and pouring after wetting, to avoid the setting of the gypsum and gumming up the apparatus before the gypsum sets.

All molds, tools, etc., must be cleaned after each casting, to prevent premature setting of the next batch due to crystallized particles left from the old.

Forms can normally be removed within 15 minutes after casting.

(9) Cast gypsum tile thus mixed with chips vary greatly in weight, and may be anywhere from 50 to 90 pounds per cubic foot when dry. The amount of water used also has something to do with it; the large excess of water customarily used in mixing rendering the casting more porous and of lighter weight when dried. This porosity is also bad in increasing the ability to absorb water after drying. But without the use of the excess water, gypsum sets too quickly for convenient handling.

(10) Linseed oil, neat-foot oil, and several others, painted on to the forms before casting, prevent the gypsum from sticking to the forms, and render them easily cleaned. Several lubricating greases are also good.

(11) Gypsum blocks wet or dry have negligible tensile strength. Strength in sheer is extremely variable, depending on porosity, chips in mixture, etc.; it however may be depended on in well cast blocks in the above proportion with chips at not less than 50 pounds per square inch dry. Compressive strength under the above conditions as to mix and dryness, is about 50 pounds per square inch with a safety factor of 5. When saturated with water, this may be reduced to as low as 15 pounds, with the same safety factor, or about 75 pounds per square inch in ultimate strength.

(12) Gypsum should never be used under conditions exposed to the weather without some treatment. Its ready absorption of moisture, weakens it; and when frozen, causes it rapidly to disintegrate. It is also readily abraded.

(13) Mixed with some of the magnesium compounds, it is partially transformed into epsom salts, and is rendered practically useless as a structural material.

(14) Gypsum very slightly shrinks on setting, gripping tightly any reinforcement that may be used in it.

(15) Gypsum chip blocks are exceedingly elastic—far exceeding in this respect any other structural material.

(16) The heat conductivity of gypsum is about two-thirds of that of asbestos. I have no exact data at hand, but make the above statement from experiments conducted by Professor Ordway and published in the *Trans. A.S.M.E.* This is very low for a common structural material; and high heat insulation results from its use.

THINKING WITHOUT A BRAIN

The usual view of psychologists and physiologists has been that thinking, *i.e.*, that effort of the brain which consists in the last analysis of association, is possible only to animals high enough in the scale to possess a brain—in other words, a central nervous system with one ganglion of superior development. Some remarkable experiments recently made at the Oceanographic Institute of Monaco, and described in the

Bulletin of that learned body, for August 17, 1920, indicate that the power of associating reflexes is not confined to animals with a central nervous system, but also exists in such humbler creatures as the Hermit Crab. This little creature, which has always excited a good deal of popular interest from its well-known habit of borrowing the discarded shell of a periwinkle, or some other univalve mollusc, to keep house in, was the subject of the experiments in question, the following résumé of which we find in the *Revue Générale de Science* (Paris) Jan. 15, 1921: The so-called responsive reaction of living creatures can be divided into two groups: Congenital reactions and acquired reactions; the former are those natural or simple reflexes which occur as a response to any stimulus of the senses, while the latter depend upon individual experience and represent *associated reflexes*, which are due to neuro-psychical reactions.

A *natural associated reflex* is produced when an external stimulus which hitherto had caused no reaction on the part of the organism, has been associated for a number of times with another stimulus possessing the power of occasioning the said reaction, and, therefore, acquires this power of excitation, even when the primary stimulus is lacking.

An *artificial associated reflex* is established when an experimenter purposely associates a stimulus with another stimulus capable of producing a given reaction of one sort or another, as of the muscles, the vaso-motor nerves, one or more of the glands of secretion, etc. In the beginning the artificial associated reflex is not differentiated; it is obtained in response to stimuli of different degrees of intensity, as, for instance, the varying shades of a single color; or to take another example, if the responsive action is on the part of the foot the organism responds at first to the associated stimulus with movements of other parts of the body also.

When the associated reflex has once been formed it can be gradually differentiated by a special method of associating the two concurrent stimuli: this method consists in always making use of the principal artificial stimulus, together with the direct stimulus which reinforces it; accessory stimuli are employed without reinforcement. If this method be carefully followed differentiations of a very high degree of precision can be obtained. In the case of a dog, for example, trying to respond to an auditory stimulus, the modification of the exciting sound by 1/4 to 1/7 of its tone is sufficient to suppress the established associated reflex.

If the associated reflex be repeated from time to time without an association with a direct reflex, the associated reflex will gradually be extinguished and will become generalized, *i.e.*, its special differentiation will disappear. It is also true that it is possible to suppress the associated reflex quite rapidly, by using a sort of artificial brake, so to speak; such a brake is formed by a new external stimulus which is made to operate simultaneously with the associated stimulus and without the action of the original direct stimulus. Or, again, such a brake may consist in an increase of the frequency of the stimulus, or, even by causing the natural stimulus to act at intervals too near each other.

The associated reflex destroyed by such means may, however, be "unbraked," *i.e.*, made operative once more by employing the method originally used for producing it, or merely by increasing the length of the interval between the stimuli.

When the associated reflex is motor in character, it can be differentiated in the case of color, for example, not only as regards different colors, but even with reference to shades of the same color. Or, again, different reactions of the skin to the stimulus of heat may be obtained according to the point at which the stimulus is applied.

Pawlow's researches with respect to the exciting of the salivary glands, led him to conclude that only the associated stimulus is connected with the centers found in the gray matter of the brain and that the responsive reaction to this associated stimuli (*i.e.*, the flow of saliva) is independent thereof. Furthermore, he denies the existence of secretory centers in the gray matter of the cerebrum.

Bechterew's studies of the dorsal flexion of the foot, on the other hand, appear to prove that the responsive motor reaction and its localization result directly from the activity of centers in the cerebral matter.

Mikhailoff's Experiments with Hermit Crabs

Mr. S. Mikhailoff of the *Oceanographic Institute* at Monaco, has recently made experiments along similar lines, except that he has endeavored to establish an *artificial reflex in invertebrate creatures*, which, according to general opinion, lack a central nervous system and, consequently, possess no brain. His researches had as their object the answering of the question as to whether neuro-psychical activity, *i.e.*, thinking, is possible without a brain.

His first series of experiments was made with an ordinary hermit crab, *Pagurus striatus*. Single specimens of this crab were placed in each of several glass aquariums, containing running water, and covered with a light wooden box, having on one side shutters containing screens of different colors, and on the opposite side an observation window.

Three principal reactions are observable in the hermit crab:

1. If one touches it, it retires into its shell.
2. If food is offered it, it moves forward and spreads its "pinchers," at the same time rearing itself on its hind claws, and makes an attempt to seize the object offered.
3. If it be turned upside down it comes out of its shell and then resumes its normal position.

The first step in the experiments was to accustom the crab to remain for some little time with its shell turned upside down. In this position the simple reflex is easy to obtain in response to the stimulus of touch, which causes it to withdraw into its shell. The next step was to associate with the tactile sensation (caused by touching it with an iron wire) red light passing through the screen in the open shutter. This was repeated every thirty seconds and 30 to 100 experiments per day were made. The associated reflex was found to be acquired with comparative stability at from the 8th to the 10th day, so that the crabs retired into their shells at the mere sight of the red light, and they repeated this action more than ten times on end without having the stimulus reinforced and as much as 25 times, if the interval between the stimuli was increased. Furthermore, the reflex was quite well differentiated, since the animal refused to respond to anything except the color which was the "educating" stimulus, even when shades of red very near this were employed.

After having obtained a series of associated reflexes which finally end in the extinction of the reflex, it is only necessary to reinforce it two or three times by means of the tactile stimulus, to cause the reappearance of the associated reflex and to re-establish a series of differentiated associated reflexes.

Upon the 36th day after the formation of the reflex and the 26th day since the beginning of its slow extinction, results were obtained which showed that the associated reflex was still both differentiated and stable.

Summary

These experiments definitely prove that a complex neuro-psychical activity is possible in animals having neither a cerebrum nor even a central nervous system. In the case of man, however, the power to distinguish differences between colors and their shades is located in the gray matter of the cerebrum.

The following facts may be regarded as having been fully established by the experiments in question:

1. It is a mistake to compare the ganglional nervous system of invertebrate animals to the sympathetic system of vertebrate animals.
2. These methods enable us to study the functions of the various parts of the nervous system by "cutting out" after having established an associated reflex, one of these parts and studying the influence of this upon the associated reflex. It is possible to establish an associated reflex in response to any external stimulus whatever.

The Manufacture of Artificial Leather

The Raw Materials, the Processes and the Machinery of an Industry of Recent Growth

By Ismar Ginsberg

ARTIFICIAL leather may be defined as a material which has as far as possible the color, grain and external appearance of real leather, and which, because of certain properties of flexibility, resistance to wear and tear and ease of working, can supplant leather in many of its applications. A great many artificial leather products have been made and are on the market at the present time some of which resemble in no way whatsoever the material that they are intended to replace neither in their appearance nor in their properties nor in their cost. Moreover, even the best of the artificial products can hardly approach real leather in elasticity, flexibility, resistance to wear and tear, and permeability.

In spite of this, the interest in artificial leather at the present time is very great, for it is hardly conceivable that all the numerous articles that are made from leather substitutes, such as traveling bags, footwear of various sorts, book bindings, seats of chairs and other furniture, automobile finishings, etc., etc., could possibly be made out of real leather. There is certainly not enough leather produced to supply all our wants. This subject is therefore of importance to all, for we ought to know just what this substance is that we sometimes buy under the misapprehension that it originally came from the cow or calf.

THE CLASSIFICATION OF THE PROCESSES OF MAKING ARTIFICIAL LEATHER

Although the processes of manufacturing artificial leather are numbered by the thousands from the standpoint of the various materials entering into the compositions, nevertheless all these processes can be classified into two classes. The first general method of manufacture resembles that used in the making of oilcloth. This consists in applying an undercoat of an initial coating to a supporting background made of jute fabric or other animal or vegetable fibers. This undercoat has the property of making the fabric comparatively rigid, while in no way detracting from its flexibility and at the same time it acts as a close and solid tie between the final coats that are to be applied later and the underlying support. After a sufficient number of other coats have been applied the impression or the grain of the particular kind of leather that it is desired to imitate is pressed into the top coat by the aid of calenders of special process.

The second general method of manufacture is based on the principle of making kamptulicum, the forerunner of linoleum. This consists in grinding different substances to the proper state of fineness and in binding them together by the aid of suitable binding agents by pressing the composition in appropriate molds to form layers of varying thickness and homogeneity according to the uses to which the products are going to be put.

RAW MATERIALS USED

One of the principal raw materials used for the purpose of making artificial leather is leather refuse of all sorts, either reduced into the state of a powder or in the form of sufficiently fine scrapings. Leather refuse is in itself a high grade raw product for use in making these products, and very often it is replaced by paper refuse, old pasteboard, hay, straw, wood pulp, etc. The agglutinants used are strong solutions of rubber or resins, linseed oil or varnishes with a linseed oil base or any of the other drying oils, solutions of nitro-cellulose or cellulose acetate. These binding agents have the additional function of conferring the property of impermeability and waterproofing on the finished product. In the manufacture of artificial leather to be used especially for the making of shoes, mixtures are made with tarry or pitchy bases containing silicate of soda or other silicates and various filling materials.

Compositions containing as bases agglutinants which are originally soluble in water, such as casein, strong glue, gelatine, etc., when rendered insoluble by the well-known methods (such as by the use of formalin, etc.), have no practical use. In fact there is no real insolubility and the mass immediately swells up and absorbs water. In this condition it is no longer cohesive in any way nor does it possess any resistive powers.

In general, no matter what method is used, the manufacture of artificial leather requires quite a costly installation, which resembles very much that used in the linoleum industry. (For details of the apparatus used, etc., see *Rev. Chem. Indust.*, October, 1911).

THE USE OF PAPER WASTE IN ARTIFICIAL LEATHER COMPOSITIONS

The idea of using paper waste for this purpose is an old one and during the past war it was resurrected in Germany with some degree of success. Kummer, in 1830, originally proposed the use of this raw material. His method was to mix paper or other vegetable waste together with drying oils or resinous varnishes, adding a little iron filings or fine sand, and to subject the mixture to great pressure. It was claimed that the shoes made from this substance were very resistant to water and as strong as real leather shoes.

Unfortunately, actual usage proved the contrary to be true and this holds good with varying degrees of certainty for all artificial leathers made from a paper base. The trouble is that the drying oils which are supposed to render the product impermeable to water are not themselves resistant to water. They generally absorb it and the result is that shortly afterward the leather product loses its cohesive properties and just falls to pieces. If it is desired to remedy the porosity then it is necessary to dry the product at a high temperature, but this only results in making the coating very brittle. Brittle leather, of course, soon cracks and tears. Its life is very short.

The resinous compositions are much more resistant to water than the others, and especially so when nitrocellulose is mixed with them. The nitrated mixture is obtained by soaking, then removing the fibers from the paper waste, drying them rapidly and mixing them with a solution of cellulose nitrate or cellulose acetate and rosin. The composition is then pressed at a very high pressure. The addition of a little castor oil lends flexibility to the mass, while in no way harming the resistivity of the composition to water. Nevertheless the product that is obtained does not bear any resemblance to real leather.

THE BEST LEATHER IMITATION

The imitation leather that looks most like the real thing is made in the manner similar to that in which linoleum or oil cloths are made. It does not make any difference what the material is that constitutes the underlying support, be it either cotton cloth or linen, jute, or hemp, or even silk or wool or simply isolated fibers or paper itself, it is only necessary to see that either the back or the front or both is covered completely with the coating in order to obtain a good product. The determinant factor in the quality of the finished product is the nature of the coatings and the way in which they are applied.

THE HISTORY OF THE INDUSTRY AND THE PROCESSES USED

(There are so many processes and the development of the industry has been so great that it would be impractical to

detail all the various steps in the history and describe all the methods of manufacture. Only the more important facts will be given here. For complete detail the reader is referred to an article occurring in *Revue de Chimie Industrielle*, 30, 7-11, 35-40.)

It is claimed that the first manufacture of artificial leather was carried out in Germany. This was merely a composition of matter with a glue base. The use of textile backgrounds developed soon afterward. Almost from the very outset the leather dust and refuse collected from tanneries and factories where leather articles were made was used in compounding mixtures for the manufacture of artificial leather. The first agglutinants used were rubber and the various resins. Afterward rubber was replaced by boiled linseed oil.

FIG. 1. THE MACHINE USED FOR COATING ARTIFICIAL LEATHER

Winkler has produced a material that resembles leather very much and which is used for the manufacture of gloves, gaiters and caps for containers. His process consists in coating fabrics with a composition containing rubber, glycerine and mineral substances. By passing the fabric through carding cylinders a certain degree of porosity is given to it.

The Pantasote Leather Co. manufactures a product used as a leather substitute which consists of four superimposed layers, viz., a bottom layer of coarse fabric, a thick solution of rubber, a fine fabric and a thin fluid solution of rubber. The entire product is compressed in such a manner that the designs or grain is not reproduced in the coarse material forming the background.

THE USE OF ALBUMEN AND SIMILAR SUBSTANCES

Many processes are known in which albumen, casein, gelatine and similar substances are used. In these compositions it is customary to cause the albuminous coatings to coagulate by means of treatment with ammoniacal or alkaline tannic acid solutions. The coagulated coating is then covered with a layer of rubber dissolved in various solvents, such as turpentine, benzine, etc. The final coat consists of a solution of soluble cotton or collodion. In order to gain flexibility molasses, glycerine or more often castor oil are added.

RUBBER COMPOSITIONS

An artificial leather has been made from a pasty mixture of leather refuse ground up very fine and mixed with a solution of rubber. The mixture is applied to the fabric body in the form of sheets which are pressed into the cloth in a special calender roll. India rubber, gutta percha or balata solutions are also used for impregnating fabric woven from a mixture of animal and vegetable fibers. After impregnation the rubber is thrown out of its solution by suitable means and forms an even layer over the fabric background. In another process balata rubber is dissolved in toluene to which dextrine, glycerine, gelatine and a small quantity of sodium carbonate are added. The very viscous mixture that is obtained is worked into ramie fibers.

FINELY DIVIDED METALS

There is an interesting process for making artificial leather in which a vegetable oil is used mixed with substances which are soluble in the oil and with finely ground metals such as aluminum, copper, iron, brass, etc.

ARTIFICIAL LEATHER WITH A CELLULOSE XANTHATE BASE

Artificial leathers made from a cellulose xanthate base are useful for certain purposes where it is not necessary that the product be very resistant to wear or possess great strength.

The textile support is made by felting an animal fiber cloth or cotton on both sides. Then the felted cloth is covered with a coating of cellulose xanthate by passing the same through a solution of the material. This coating is then covered in its turn with a coating of rubber or gutta-percha.

The felting is a very important operation and on the effectiveness with which it is carried depends to a great extent the quality of the finished product. Inasmuch as animal fibers lend themselves more readily to this operation, they are used preferably as the supporting fabric, even though they are more expensive than the vegetable fibers, such as cotton.

The solution of cellulose xanthate is prepared in the following manner: Cotton wastes are macerated in a solution of caustic soda, containing about 15 per cent NaOH. About a third of the solution is then removed and then about 40 per cent of carbon disulfide is added, figured on the weight of the cotton. The process is then continued in an autoclave until the mass becomes soluble in water. Enough water is added to give a solution of the desired concentration. To this solution castor oil, soap and coloring matters are added and it is then ready for use.

The impregnation of the felted cloth is carried on in practice by the help of a slight vacuum. This can be done in two ways. The vacuum can be attained directly in the impregnating vat by the use of a suction pump and the cloth in this manner is impregnated with the xanthate solution as soon as it enters the bath. Another way is to heat the rolled cloth strongly and make it pass over a drum which is heated with steam and then have it immediately dipped into a solution of the cellulose xanthate. After the cloth has been impregnated it is dried while being subjected to a slight tension by stretching the same between fixed supports. The next operation after drying is the washing of the product by passing it through a tank of water and thereafter through a chamber where the xanthate of cellulose, entrained in the fibers of the cloth, is decomposed by means of superheated steam and the cellulose is fixed on the fiber. The alkaline salts which are formed during this process are removed by a further washing. When an artificial leather of considerable thickness is desired, the process is repeated

as many times as necessary, each operation being followed by an immersion from 6 to 8 hours in cold, running water. In this way a number of coats is formed on the cloth support until the finished product is thick enough.

After the proper thickness has been reached, the coated fabric is hung up to dry in long drying houses. When dry, it is passed through a bath containing a solution of 15 to 25 grams of rubber or 75 to 100 grams of gutta-percha in a liter

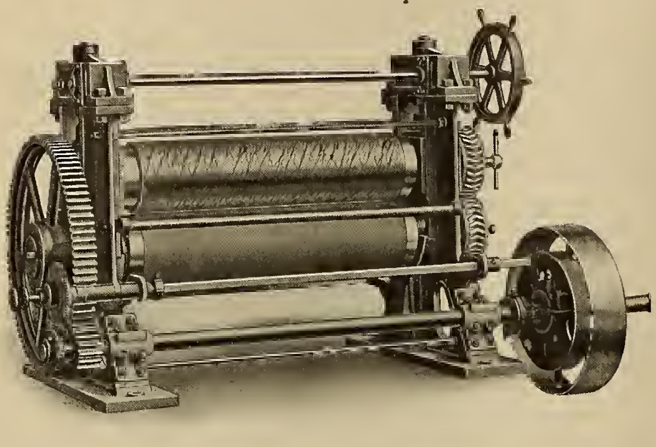


FIG. 2. TWO-ROLL EMBOSSING MACHINE

of carbon disulfide or benzine, mixed with a little gum damar for light colored leathers and with asphalt, rosin or stearin pitch for dark colored products. The quantity of the latter materials used varies from 2 to 10 grams per liter according to the rigidity or flexibility that it is desired to produce in the product. These properties however depend to a great extent on the concentration of the cellulose xanthate used in forming the undercoats and on the nature of the xanthate itself.

In drying the leather the solvents of the rubber may be recovered and reused. The artificial leather is then passed through embossed rolls which give it the grain of any animal of the sea, air or land.

WOOD FIBERS AS A BASE OF ARTIFICIAL LEATHER

It is well known that sulfite wood pulp can be molded very readily under pressure, but when the finished product is passed through calendering rolls, then it breaks at once and falls to pieces. This can be avoided by impregnatng the wood pulp with a solution of paraffine in light petroleum distillates. The material is then flattened between the rolls under a moderate pressure so as to avoid crushing the fiber. To guard against this happening the top roll is provided with springs which take up any excess pressure. As the strips of wood pulp pass through the rolls they are given a torsional motion. Then they are passed through the opposite direction to flatten out the twists. In this way a veritable molding together of the fibers is attained, which action is promoted to a considerable extent by heating the rolls by means of steam. The pulp is generally put through heated rolls as a final processing and receives a calendering treatment as well in order to increase the impermeability. This product is then used as a support for manufacturing artificial leather.

LEATHER CLOTH—NITROCELLULOSE BASE

There is hardly any question that the best artificial leathers are made from a cellulose nitrate base. There appear to be numerous processes which use this cellulose ester in various forms and in various ways. In one case a mixture of celluloid with cellulose acetate is used. A nitrocellulose soluble in an ether alcohol solution mixed with carob flour has been used, but this is of no real practical value.

The supporting fabric used in these processes may be of various sorts in accordance with the use to which the leather is going to be put. Generally for ordinary leather, such as is used in the upholstering of furniture or in covering the cushions of automobiles, there is used a cotton back of a high grade fiber in a dull blue shade. The cloth is woven very closely and is very strong and durable. The closeness of the weave is important in that it permits the first coat of nitro-cotton to secure a firm grasp on the cloth and also does not permit it to penetrate the fiber and smear up the back of the fabric. Felted cloths are also used in cases where a fancy product is required or where it is desired to make a very thick leather.

The principal raw material used in these processes is cellulose nitrate or nitrocellulose, as it is generally called. Cotton is nitrated not only for the purpose of making smokeless powder and gun-cotton, but also for use in the manufacture of celluloid and artificial leather and lacquers. In each case the degree of nitration that the cotton is subjected to is fixed between definite limits as the properties of the nitrate vary very considerably with the amount of nitrogen that it contains. The nitro-cotton that is employed in making leather must contain in the neighborhood of 12 per cent nitrogen. The type of product that is very well suited for making celluloid is altogether unsuited for artificial leather and so it is with all the others. It is remarkable that the principal reason for this great variance in the properties of the nitro-cotton is the nitrogen content of the same. Just a few tenths of a per cent of nitrogen in the cotton makes a very considerable difference in its solubility in various solvents and hence in the uses to which it can be put.

It is aimed in the manufacture of artificial leather to use as soluble a nitro-cotton as possible. The higher the nitration of the cotton the more fluid it becomes, that is the more soluble it becomes in the various mixed solvents that are used in the manufacture of the leather. Solubility in this case means the extent to which the nitro-cotton will dissolve in a gallon of mixed solvents and still give a mixture which will be able to be worked within the artificial leather machines. Some cottons are more soluble than others, and generally the more soluble the cotton the more expensive it is, as the more it costs to manufacture because of increased acid consumption and the less the yield of the nitrated product from the cotton linters used to make it.

The nitro-cotton is dissolved in a mixture of volatile solvents. The proper selection of this mixture and the proper admixture of non-solvents is a very important technical detail

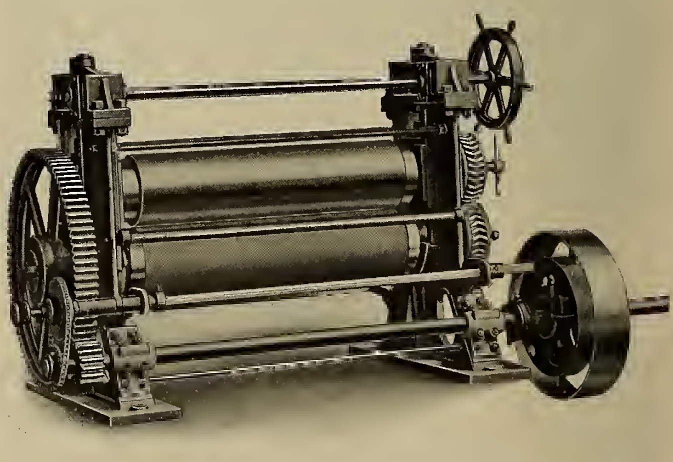


FIG. 3. EMBOSSING MACHINE OF THREE ROLLS, THE ENGRAVED ONE IN THE CENTER

in the artificial leather manufacture and has a very great bearing on the final cost of the finished product. In making the leather all of the volatile solvents and non-solvents are lost by evaporation, unless there is an adjunct solvent recovery plant in which the evaporated vapors are caught and condensed or absorbed in proper absorbents, recovered and rectified for reuse. This expedient has not been adopted to any great extent as yet in the industry. The solvents, viz., acetone,

ethyl acetate, light acetone oils, methyl ethyl ketone, etc., are generally much more expensive than the non-solvents, such as benzol and wood alcohol or denatured alcohol. Hence it is very desirable to keep down the proportion of the solvents used as far as possible, and at the same time have enough of the nitrocellulose dissolved in the working mixture to give a coating of nitro-cotton of the proper thickness and tenacity. This is another reason why it is very important that the nitrocellulose be as soluble as possible in the solvents to start with. In making up the mixture of solvents and non-solvents the aim of the manufacturer is to obtain as cheap and as effective a mixture as possible. Cheapness is procured by using much benzol, but too much cannot be used or else not enough of the nitrocellulose will be dissolved. Too little solvent will be just as costly in the long run as too little non-solvent. The mixture of solvents contains as a general rule about one part by volume of ethyl acetate or any other active solvent, two parts by volume of denatured alcohol and three parts by volume of benzene. The addition of the benzene to the solvent ethyl acetate, for example, decreases its solvent action very considerably, while the effect of the addition of alcohol is not so marked in the same respect. It appears that the alcohol is on the border line of being a solvent of the nitro-cotton and therefore its use does not cut down the solubility of the solvent too far. Sometimes just benzol and ethyl acetate are used, 30 per cent of the former and 70 per cent of the latter.

Various oils and pigments and fillers are mixed with the nitrocellulose solutions to produce different finishes and colors. Castor oil is used to give the leather its flexibility. The oil may be partially oxidized or not, but it is found that the oxidized product will give the best results.

The solution of nitrocellulose is tested for its viscosity in order to be able to tell whether or not it will be workable in the machines. The test is made by observing the fall of a steel ball bearing of definite dimensions through a fixed distance, usually ten inches, within a glass cylinder, whose dimensions are also standardized, at the room temperature. The temperature is important for the viscosity decreases rapidly as the latter increases. In the industry a limit of viscosity is set beyond which the machines will not handle the solutions. The main difficulty is to obtain the working viscosity and still have sufficient of the nitro-cotton in solution to give the proper thickness and quality of coating. This is the reason why it is not practical to dissolve celluloid scrap and old moving picture films in a gallon of the solvents and use the solution as such. These substances cannot be used as primary materials in the manufacture of leather. Another reason why this cannot be done is because they do not give films which have the proper tensile or tearing strength. The leather, made with them, does not possess very great resistance to wear and a piece of furniture covered with this product would soon wear through. The celluloid scrap and moving picture film scrap are used in admixture with the regular nitro-cotton and even at that they give a product of inferior grade.

The machines that are used to coat the fabric are arranged so that one or more coats can be applied at a time. The solution of nitro-cotton is pumped over the unrolling cloth in a continuous stream, the excess running off the cloth and being collected in a suitable receiver and repumped in the same manner. The apparatus is all enclosed so that evaporation of the solvents is prevented as much as possible. As the solvents do evaporate the solutions become thicker and thicker, and consequently the original solution must be fluid enough to allow for a certain amount of thickening taking place during the progress of the manufacturing process. All leathers are made in more than one coating. There is a general relation between the thickness of the film, the viscosity of the solution, the percentage of nitrocellulose that it contains, the percentage of film scrap and other nitro-cotton substitutes in the mixture, the cost of the nitrocellulose, the cost of the labor and material, including solvents, in making a coating and the number of coatings that the finished product must possess. The successful manufacturer strikes a happy medium between all these simultaneously variable factors which gives him the cheapest product of the best quality.

In manufacturing the leather the first coat contains no oil or pigment of any kind, but only the pure nitrocellulose. This coat is perhaps the most important of all, as all the others are connected to the fabric background through it and if it does not adhere to the fabric firmly and tenaciously, then the entire film covering of the leather will be held but loosely to the fabric support. Consequently, great care is taken to see that this initial coat adheres tightly to the fabric support and to increase its tenaciousness the oils and pigments are omitted from it. The solution however must not be too thin or else it will penetrate through the fabric and smear up the back, giving a faulty product, but it must neither be too thick, or else the proper degree of adhesion to the cloth is not attained.

After this coat has been dried, then the next coat is put on. The theory of the operation is that the solvent in the second coat cuts the surface of the first coat and effects a true union with it in this manner. This is then dried and the filler coats are put on in the required number to give the desired thickness

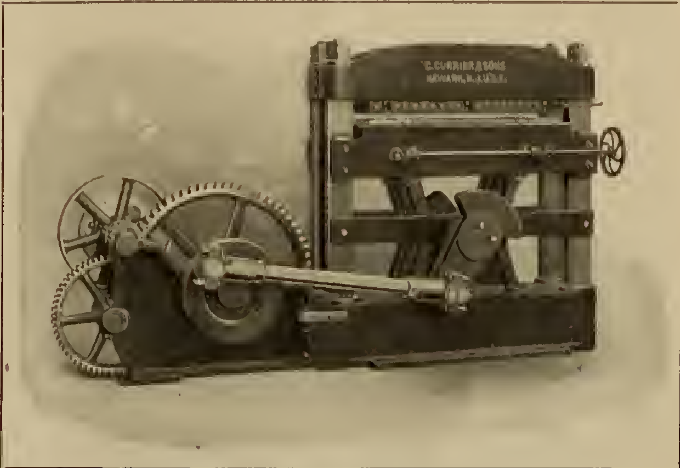


FIG. 4. EMBOSSING PRESS SOMETIMES USED IN PLACE OF THE ROLL MACHINES

of the leather. These filler coats are just what their name indicates. They generally do not contain very much nitrocellulose and can be made from film scrap, celluloid scrap, various gums, resins, clays, etc. These films do not have to possess the same degree of strength as the other coats. Then the final coat is put on and generally the leather is grained after this is done. The last operation is to put on the grained leather a thin coating of collodion cotton, which is very resistive to wear, and must necessarily be so, as it forms the coat which comes in direct contact with surfaces foreign to the leather and which rub against it and tend gradually to wear it down. The finish given to the leather can be varied to suit the purpose to which it is going to be put. Some leathers have a very lustrous appearance, others are very dull and still others are of a medium appearance. There is generally mixed with the solution last used some substance which will give the artificial leather the odor of real leather. Such a solution may be a concoction made by boiling up leather dust or may be obtained by the use of tannins.

Fig. 1 illustrates the type of machine used for coating artificial leather. It is called a coating machine. There are generally several of these machines in an artificial leather plant so that the application of many coats to the fabric background may be facilitated as much as possible. This machine stands in working position before the hot room where the coated leather is dried. The roll of fabric unwinds and

the cloth passes over a drum. Before it reaches that point it has received a coat of dope and the knife has scraped off all the excess dope that remains on the cloth. The dope, which has been mixed in the regular type of mixing machines is fed to the fabric through a nozzle which is placed somewhat in front of the knife. The coated fabric passes under one pulley and over the machine and another pulley on to the festooning device. There fingers catch hold of the cloth at certain definite intervals and carry it into the hot room. The artificial leather is strung from ceiling to floor, hanging in loop after loop, for drying, which is accomplished by means of steam coils. When the leather is dry, it is removed from the hot room and passed through the coating machine again to be given another coat of dope. After it has received the sufficient number of coats, it is ready for the embossing rolls.

There are two types of machines that are used for this purpose. One is the embossing rolls and the other, the embossing press. The embossing roll machines are shown in Figs 2 and 3. The first cut shows a two-roll machine and the latter a three-roll machine. In Fig. 2 the engraved roll is designated above and the counter roll below. The former is made of hammered steel while the latter is made of specially manufactured paper pressed on steel mandrils. The leather is passed between the two rolls and receives the impression of the design that is embossed on the steel roll. The paper counter roll serves to take up the compressive action of the steel roll against the coated fabric, which would otherwise be torn or injured in its passage through the machine. In the three-roll machine the engraved roll is situated between the two paper counter rolls. These machines are made smaller than the two-roll machines and are used on small widths of leather and in making special grades. These types of machines have arrangements for winding and unwinding the rolls of coated fabrics. The action of the embossing machines is to give the artificial leather the appearance of real grain leather.

The embossing press is shown in Fig. 4. The engraved plate and the counterplate are caused to come together with a certain degree of pressure or rather to within a certain degree of contact by means of a connecting rod-crank arrangement. The machine will emboss about 18 inches of leather at a time. The feeding of the leather into the machine and its removal after embossing has taken place is an automatic action which is synchronized with the raising and lowering of the bed plate. This type of machine is not as rapid as the roll embossing machines, but possesses certain important advantages over the latter. It is possible to obtain a grain which resembles the real leather more exactly with the press than with the rolls. The reason for this is that while the rolls are engraved from pictures of the real leather grain or for that matter from the leather itself by reproduction in a drawing, the plates in the press are made directly from the leather itself by an electroplating process. All the peculiarities of the leather are produced in this way and a product is obtained which defies detection. Another advantage lies in the fact that the adjusting of the machine is very much easier than in the case of the roll embossers. When a seam in the leather is reached, that is where one end has been joined together with the beginning of another roll, the roll machine has to be stopped and the rolls readjusted to take the seam. Otherwise if the seam was not of the same thickness as the piece of leather that has passed through the leather is apt to be torn by the rolls. In the press such exact adjustment is not necessary. The press is stopped and the seam is passed through the same without being embossed. Then the press continues operating. The leather cloth shows a distance of about one inch on either side of the seam which is unembossed.

THE CHEMISTRY OF THE THYROID GLAND

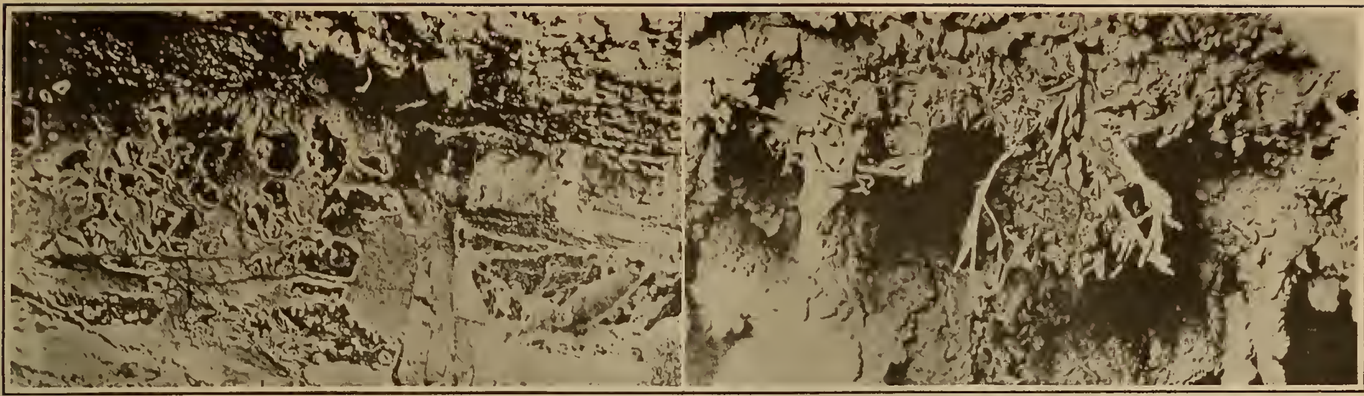
THE thyroid gland is now recognized to be one of the most important organs in the entire body. Situated in the neck in front and to one side of the larynx, it consists of two, round, lateral lobes, connected by a sort of "isthmus." It is covered with a characteristic form of epithelium and filled with a slimy mass—the so-called "colloid." This body is secreted from the cells which surround it. It consists chiefly of an iodated aluminous body called iodo-thyreo-globulin or more briefly, thyriodine. This substance possesses the function of furthering the general processes of oxidation; it regulates the normal processes of growth and development.

The greatest need of this substance experienced by the organism is during youth, when the processes of oxidation are most vigorous, and on this account the thyroid gland is much heavier in proportion to the weight of the body in children than in adults. Furthermore, we are justified in believing that the cells of the glands function more vigorously in the young. An enlargement of the thyroid gland consisting in a proliferation of the epithelium with a formation of follicles, as in the case of goitre, occurs when the thyroid gland in its natural size is incapable of furnishing the body with the amount it needs of thyriodine. This may take place whether there be provided a sufficient or an insufficient amount of the materials employed by the thyroid gland to form this substance. When an insufficient amount of the raw materials is furnished to the epithelium of the follicles, the epithelium is increased in amount to abstract the proper amount of raw material from the blood. This purpose is also served by a great increase in the blood vessels.

It appears that the thyroid gland always receives sufficient material for the formation of that component of the thyriodine known as globulin. But this is not the case with the other component iodine. In fact this chemical element is present in the blood in such minute quantities that it has hitherto been impossible to detect it by ordinary chemical methods. It is quite certain, however, that traces of it must circulate in the blood since there is no other way in which it could reach the thyroid gland. The amount of iodine in the blood depends chiefly upon that contained in the food of the individual, and this varies according to the locality. We may also take into consideration, perhaps, the traces of iodine found in the atmosphere along the seacoast and taken in through the lungs. In general the farther from the coast any sort of flora or fauna are found, the poorer they are in iodine. In any neighborhood where the inhabitants are free from goitre it will be found that the food supply is richer in iodine so that the thyroid gland obtains more of this element.

The most serious consequences of the formation of too small an amount of thyriodine in the thyroid gland are myxiedema cretanism and a "deaf and dumb" condition. These diseases do not usually take on an intensive character during youth because of the fact that during this period the over-development of the thyroid gland affords a certain amount of protection. But the thyroid gland of a person suffering from a goitre becomes senescent unusually early, and becomes subject to an extensive degree of atrophy. This atrophy sometimes causes a very considerable loss of weight in the gland. In this condition of advanced atrophy the gland is no longer able to furnish the organism with the necessary amount of thyriodine and the result of this is a still greater senescence.

The opposite condition to that of a decreased internal excretion of the thyroid gland follows those conditions in the body which accompany an intensification in the functioning of the thyroid gland; the most serious affection due to this cause is Basedow's disease. This malady presumably arises when the capacity of the cells of the body to form thyriodine is maintained to a greater age than usual. The cells form more thyriodine than is requisite for their normal functioning and this causes an irritated condition. The nervous symptoms which are prominent in Basedow's disease being the most obvious signs of it, have their cause in the lack of congruity between the amount of fixated thyriodine and the capacity for reaction of the nerve cells. Since this incongruity can never be very great in youth Baredow's disease is seldom found in children and only in a very mild form. It is not until after puberty that this disease appears frequently.



CHARACTERISTIC FORMATIONS IN KENTUCKY'S GREAT ONYX CAVE

Must Humanity Perish of Thirst?

The Possible Desiccation of the Earth Through the Depredations of Underground Watercourses

MUCH interest has been felt by men of science of late years with respect to what many of them believe to be the inevitable though, of course, very gradual desiccation of the earth which, of course, implies the eventual destruction of all life as we know it, since vital functions are impossible without moisture. This question has been discussed among others by such well-known men as Professor Lowell, Sir Archibald Geike, l'Abbé Moreux and the other French authorities, M. Haug and E. A. Martel. The latter authority has recently published an interesting treatise upon subterranean waters (*Nouveau Traité des eaux souterraines*, 8vo, 840 p. (Paris), Doin, April, 1921), one chapter of which is especially devoted to this subject. This chapter which is called *The Era of the Circulation of Subterranean Waters and the Desiccation of the Earth*, sets forth in detail the chief facts of our present knowledge of the waters whose course lies not upon but beneath the surface of the earth, dealing particularly with the results of the daring explorations which have been carried on for the last forty years or so, in the caves of Austria, France, Belgium, England, Spain, Italy, Switzerland, the Balkan Peninsula, the United States, etc. This chapter is, of course, too long to be reprinted here, but we give below an admirable abstract of it which appears in *La Nature* (Paris) for May 7, 1921.

The numerous facts which have come to light within the last 25 years have enabled us to form the opinion that the most ancient known phenomena relating to the circulation of underground waters and the effects produced by them upon the crust of the earth go back at least as far as the secondary epoch in geology. The late and much regretted geologist, Oehlert, was even of the opinion that in the vicinity of Laval certain carboniferous calcareous strata have been hollowed into pockets and gullies by the force and dissolving power of water before the coal age. As early as 1861 Delesse believed that the surface waters had already begun to diminish.

Many explorers, particularly Flamand, L. Gentil, Henri Hubert, Capt. Augiéras, etc., etc., have held the opinion that the dried up *oueds* or ravines of the Sahara carried great volumes of water in the Quaternary era.

De Lapparent thought that during that same era the bottom of the Grand Cañon in Colorado was filled with a much more powerful current than that of our time. This same view is held by W. Kilian with regard to the Guil of the Upper Alps and by David Martin with respect to the vicinity of Gap. The lowering of the level in the ancient lakes of Lahontan and Bonneville (the Great Salt Lake in the United States), the ancient river borders and fluvio-glacial terraces, the fossil thalwegs of the Cevenol Causses, the calcareous plateaus of Provence, the desiccation of certain regions in Africa, Central Asia, etc., have long been pointed to as signs of an increasing spread of dryness in the crust of the earth.

But most of all it is the recent researches in the interior of the ground itself which have "transformed from a hypothesis to a certainty the idea that the waters are gradually making their escape into the sub-soil or calcareous regions, and that there is a substitution among these lithological formations of a modern subterranean circulation for an ancient surface circulation." M. Martel enumerates and describes a great many very curious examples of the disappearance of springs, the deepening of subterranean rivers, the going dry of wells, etc., which make the future desiccation of our globe seem inevitable. He says "humanity must prepare for a fight with thirst."

One of the most convincing of the arguments offered to this effect is the perforation of the bottom of the upper galleries in caverns where subterranean rivers have dried up in the course of ages through an actual drawing off of their waters into profounder depths. This has been noted particularly in many of the caves among the Pyrenees during the researches made therein in 1908 and 1909 by M. Martel and his colleagues under the auspices of the French Bureau of Agriculture. Here there has even been mapped out the fossil subterranean course of the Traun (to the caverns of the Dachstein) which formerly flowed within the mountain at a level 1000 meters higher than that of today. In the Mammoth Cave of Kentucky, the largest cavern in the world (extending for 100 km.), the upper galleries are perforated repeatedly in this manner by great orifices through which their ancient waters have escaped.

It was not until 1916 that it was proved by M. Lahner, through his exploration of one of the two most profound abysses into which man has thus far ever succeeded in descending, the Sarcotic Grotto (315 meters) that the *polje* of Montenegro which lie at an altitude of 660 to 850 meters, are dried up.

Even under our very eyes we may see the capture of waters by the depths below in the losses to which the Danube and the Aach (in the Duchy of Baden are subject) still other examples of this loss of waters are found in many rivers of France. . . . The valley of the Nesque (Vaucluse) now loses on the top of Monieux (down river from Sault) its stream of water which is taken captive by the famous fountain of Vaucluse and it requires very violent storms to cause even a temporary flood to run in the bed of this superb dry ravine.

In the white chalk of Champagne and of Caux, a number of the outside thalwegs are quite dry and the water courses which once filled them must be sought beneath the earth (lower Seine, Marne, etc.) but while authorities agree pretty well with a few exceptions, as to the greater force exerted by

TWO SUBTERRANEAN WATERCOURSES, ONE IN PICTURE AND ONE IN DIAGRAM

Left: Ornamental columns in a Kentucky cave. *Right*: Plan of Montenegro's famous cavern, from the entrance 900 meters above the sea to the lowest point reached by exploration at 570 meters

streams of water in ancient geological eras, there is a lively dispute as to whether this process of desiccation has been actually manifested during historic times. . . . While a number of authorities agree that there is evidence of the "tangible visibility and rapidity of the phenomenon" in modern times, others hold that there has been no perceptible diminution of the waters upon the earth's surface during the period of historical record.

It is certainly difficult to form a positive conclusion in the matter in spite of the fact of a number of impressive cases of contemporaneous diminution in streams of water. We cannot be certain of the matter until after much further study and much more widespread observation.

Still another controversy rages as to the causes of the desiccation observed. Some geologists, including Martel and his school, ascribe it, at any rate in the case of calcareous territory, to the constant enlargement of the fissures in the subsoil, together with a decrease in the amount of water precipitated from the atmosphere. Still another school makes this last cause entirely responsible. Some writers upon this subject, such as Gregory and Haug, think that all the observed facts of the drying up process proceed only from regional changes in the distribution of rainfall, and thus remain purely local without assuming any universal character; others still, like Koenig, hold that there is a progressive desiccation of the earth's surface but declare that it is due to deforestation.

Still another group of observers believe that the phenomenon is due to the intensive agricultural cultivation of the soil, which diminishes the amount of water which would otherwise trickle into surface streams, together with the great increase in civilized countries in the number of ditches, roads, drainage canals, etc.

In a recent study of the matter presented to the French Academy of Sciences and published in the *Comptes Rendus* of that learned body for March 7, 1921, M. Chudeau sets forth his belief that the drying up of the desert of the Sahara, whose chief cause was the change of climate which took place at the end of the Glacial Period, has been completed by mechanical causes, such as tectonic movements of the earth and the barrages formed by dunes; he finds, however, that it is impossible to fix the date of the decay and disappearance of the former system of waters which supplied this area.

Apropos of the desert of Kalahari in South Africa, two studies were published by Schwarz in 1920, in which he attributes the drying up of this area to the capture of lakes or marshes by neighboring rivers; he expresses the opinion that suitable hydraulic systems would be capable of re-establishing the former condition of the country so as to make it once more habitable by man.

TWO MORE VIEWS FROM THE GREAT ONYX CAVE

The Chevalier and Tilho expeditions proved with respect to the variations in Lake Chad that while the drying up process is very slow and irregular it appears to be indubitable.

Svante Arrhenius, in a pamphlet published in 1919 entitled *The Light Course of the Planets* accepts it as a fact that there is a progressive desicca-

tion of the planet, but he ascribes this mainly to a decrease in the amount of carbon dioxide in the atmosphere, the CO_2 being little by little absorbed by the oxygen.

As for the astronomers and geophysicists such as Loewy, Armand Gautier, Emilie Belot, etc., they have long ago called attention to the fact that the moon, provided that it ever possessed any water must have absorbed it in its crust through a process of slow diffusion during the course of its cooling off. But here we touch upon transcendental hypotheses and it seems best to accept for the moment, at any rate, the practical conclusion thus expressed by M. Martel:

"To sum the matter up if it be still a debatable matter as to whether it is possible to discover in the atmosphere and in climates any diminution of the *historic degree* of atmospheric precipitation (which may be due to many factors), at any rate the three following statements appear to be practically incontestable:

"1. The reduction in the amount of running streams is pertinent to the matter, at least, since the Pleistocene geological era;

"2. The external erosion caused by water proceeds much faster than is generally believed, and it is even more rapid in the case of subterranean waters; and this in spite of their progressive diminution;

"3. The rapidity with which the gradual engulfing of waters within the crevices of the subsoil is carried on is more than sufficiently proved; this alone must lead us to the conclusion of the eventual complete desiccation of the crust of the earth. . . ."

So far as possible remedies are concerned, the most effective of all are reforestation, on the one hand, and an energetic fight against excessive and wasteful deforestation for industrial purposes on the other.

SUBTERRANEAN RIVER ENTRANCE IN THE ROCKY MOUNTAINS

THE MANUFACTURE OF CARBON PAPER

[*In a recent number of the Chemischer Zeitung a description was given by Bruno Walther of the processes of making typewriter ribbons and typewriter inks. The development of the carbon paper industry practically parallels that of the ribbon and ink business and both are intimately connected with the typewriter itself. In the following article the manufacture of the inks used for making the carbon paper is discussed first and then the making of the paper itself.—Translator.*]

These inks must fulfil certain conditions in order to render the best service. These conditions are as follows:

(1) The inks must not penetrate through the papers which they impregnate. The back of the sheet of carbon paper must be free from smudges of ink that has leaked through and must present a uniform appearance throughout. When the thinness of a sheet of carbon paper is taken into consideration, it is evident that considerable skill is required to make the paper so as to fulfil this condition.

(2) The papers impregnated with these inks should give deep black copies, or if colored inks are used, brightly colored impressions. Inferior papers give grayish impressions which are hard to read especially when several copies are made at one time.

(3) The carbon paper ink should not rub off easily; in other words the paper should not smudge. On the other hand, the ink should yield its color readily, otherwise the pressure that would have to be applied to the keys of the typewriter would be inconveniently too great. This is an important point and it means that a happy medium must be sought for. The ink should not be so soft that it comes off too easily and smears up the copies and neither should it be too hard so that it is difficult to get any impression at all.

(4) The carbon paper should yield its color with the same ease or about the same facility even several years after it has been made as on the very day of its manufacture.

The manufacture of these inks has undergone a gradual development until at the present day its manufacture is practically scientifically correct. Formerly mixtures were brushed on the paper in the cold. These mixtures, for example, were constituted as follows: One kilogram of basic nigroine was dissolved in a mixture of 0.7 kilogram of olein and 0.3 kilogram of stearin. Then 5 kilograms of a solvent, such as benzol, toluol or zylol were added. In this manner a thick mass was produced which could be painted on paper with ease. The solvent evaporates quickly, leaving behind a coating of color mixed with olein and stearin. The paper impregnated in this way is made to pass over a hot plate, which produces a luster in the ink coating. To obtain colored inks various coloring matters, such as cerasin were mixed with the inks.

When the carbon paper is made by machines, that is when the impregnation of the inks is carried out mechanically, then certain changes are made in the composition of the inks. The solvent is omitted and the stearin is replaced by the olein, in which a large proportion of the oil color is dissolved. The process was entirely satisfactory, but with one exception which was sufficient to cause its abandonment. It was found that the olein penetrated the paper rapidly and made the back full of grease spots.

There are also inks of the type that is used for inking stamp pads. These inks are made with a glycerine base, but they cannot be employed to make carbon paper because of the hygroscopicity of the glycerine. Carbon papers made with them would soon absorb sufficient moisture from the air to be rendered completely useless.

At the present time carbon papers are made only by the process in which the paper is impregnated in the hot, for it is solely in this way that a product can be obtained that will fulfil all the conditions that were enumerated above. The essential point is the composition of the ink, which does not differ in principle very much from the inks that are used for the manufacture of typewriter ribbons. The process of making these inks is as follows: The pigments are ground in a cylinder grinder with oil. Paraffine or ceresine wax is added and then a basic color dissolved in olein. The grinding should be continued as long as possible so as to get a pigment of extreme fineness. A satisfactory test of the fineness of the grinding is afforded by smearing the pigment over a sheet of paper with the tip of the finger. A properly ground pigment will show an even streak of color on the paper; an improperly ground pigment will give smudge which will have light and dark spots.

The use of a cylinder machine which is capable of being heated simplifies the manufacture very greatly. In this case the paraffine or the ceresine wax is dissolved in a mineral oil and preferably in paraffine oil or liquid petroleum. The solution is made while heating gently. The pigment is worked into the mixture and the mass is ground, while the cylinders are kept at a temperature of 40 to 50 degrees Centigrade. At

the end of the grinding operation, the solution of the basic coloring matter is added to the ink still in the hot condition. The grinding is then repeated.

When just an ordinary machine is used, the sequence of the operation is modified. The pigment is first ground with the olein and then a part of the oil, containing the total quantity of the basic color, is added. Then the mass is ground again and mixed with a hot solution of paraffine containing the rest of the oil.

A formula which is used in the manufacture of a black ink is given below: Ten parts of lamp black of the best quality are ground in cylinder machines, with 40 parts of paraffine oil or mineral oil. Great care must be exercised in this operation. To this there is added 50 parts of a solution of basic nigrosine in olein, which contains one part of the dye to two parts of the oil. Then, the mixture is ground some more. The product is brought to a temperature of 40 to 50 degrees Centigrade and is then added to a molten mixture containing 40 parts of paraffine or ceresine wax to 30 parts of oil. After the constituents have been mixed together very thoroughly and carefully, the ink is ready for use in the impregnation of the paper.

In making colored inks it is often necessary to brighten the color by the addition of zinc white or other similar substances. The coloring matters are the same that are used in the manufacture of powdered inks, but when the Milori dyes are used there must be taken into account the fact that certain oils have the property of destroying their tints completely. Consequently it is very essential that the proper oil be selected for use with these colors. In order to brighten up the colors, there are added generally basic dyes dissolved in olein, such as nigrosine, methyl violet, Victoria blue, basic red, scarlet, etc.

It is also possible to make colored carbon paper without the use of any pigments at all by mixing together concentrated solutions of basic colors in olein with paraffine or ceresine wax dissolved in hot mineral oil. The following formula can serve as a standard method of accomplishing this: Ten parts of methyl violet (the base, not the salt) are dissolved in ten parts of olein, while the mixture is heated moderately. Then there is added thereto a molten mixture of 5 parts of ceresine wax and 5 parts of mineral oil. The whole mass is then mixed very thoroughly. It is true, however, that the inks that are made without the use of pigments are not as richly colored as those which include such coloring matters in their composition.

In making copying inks, instead of pigments various basic coloring matters, such as crystallized violet, safranine, methylene blue, etc., are used. These dyes are mixed with three times their weight in oil and then the mixture is ground in machines. While the mass is being agitated, a molten mixture of 1.5 parts of paraffine or ceresine wax in 1.5 parts of oil is added. Either the paraffine oil or the mineral oil can be replaced by a vegetable oil of good quality, such as rapeseed oil.

The quality of the impregnated paper is fixed by the quality of the original paper used. There is no such thing as a paper which is at one and the same time both tough, strong and thin, which can be used for this purpose. Of course it is realized that these are conditions that are obtained but very rarely in one paper. Carbon papers for copying can be made of thicker paper than the ordinary carbon paper.

The modern process consists in impregnating the paper in the hot condition. This is accomplished by the aid of a machine, which is built in the following manner: The paper is wound on a roll and is unwound therefrom and made to pass around a metallic cylinder, which itself turns in a bath of ink. The ink on this metallic cylinder is transferred on to the paper, coating it with an irregular thick coat. The trough of ink is heated by means of an oil bath or a sand bath, which keeps the temperature at a constant level and prevents the ink from burning. The thick uneven coat of ink on the paper is then scraped in such a way that the coating of ink is made uniform throughout. This operation is effected in the hot condition by causing the paper to wind around a cylinder heated internally. The small scraper that accomplishes this work is so arranged that it can be set at any required distance above the surface of the paper and it has an up and down motion, which is of considerable advantage when inky coatings are being treated which are exceedingly difficult to make uniform.

After the scraping operation the paper passes over a cylinder chilled with water. This causes a rapid setting of the inky coating to take place and makes it assume the glossy appearance that is so familiar. Frequently the paper is given still another treatment. It is wound around heated cylinders for the second time and the melted color is spread over it by the aid of two flat brushes which are set into motion by a reciprocating arrangement. In this manner papers are produced which have a zigzag coating. Then the paper is passed over chilled cylinders again.

The finished product is either rolled into rolls or it is cut up into sheets of various sizes. The packing in cartons is done in such a manner that the carbon paper is kept protected from dust. Very often carbon paper is required that has an uncoated border of one-eighth to a quarter of an inch. In order to make such papers, the machines are provided with an arrangement that removes the ink that is applied on the edge of the paper.

FORD'S POWER PLANT MAY BE ABOLISHED

The enormous power plant at the Ford Highland Park Factory, long the pride of Henry Ford, is soon to be transformed from a gas-steam plant to an all steam plant, or is to be abolished entirely. Engineers, headed by Wm. B. Mayo, are now determining the most economic method of handling the power situation. The gas-steam plant has been in operation for over ten years and a point has been reached where gas-steam power is no longer as economical as steam power would be alone.

Two plans are under consideration. The first involves the junking of the producing gas plant and installation of additional steam boilers. This would cost approximately $2,000,000. The second plan is to eliminate the Highland Park power plant entirely and bring high tension power from the River Rouge, which would require an addition to the latter plant. This cost approximates $3,000,000.

There will be no interference with operations at the Highland Park plant while the power changes are under way. The Detroit Edison Co., which has a power house nearby, would furnish 90 per cent of the present peak power, which runs about 75,000 horsepower.—*Automotive Industries*, Vol. 45, No. 9, Sept. 1, 1921, p. 438.

THE ELECTRIFICATION OF THE AUSTRIAN STATE RAILWAYS

The early extension of the electrification of this system has been decided upon mainly on account of the heavy cost of coal since water power averaging over 100,000 horsepower throughout the year is available at the Spullersee at Danöfen. The works were commenced late in 1919. The Spullersee hydroelectric station will be worked in conjunction with the similar station on the Ruetzbach. These two power stations when completed will be capable of supplying 64 million kilowatt-hours annually. The Ruetzbach station already supplies power for the electrified Mittenwald Railway and contains two generating sets, each of 4000 horsepower. This station is to be also used for supplying the section Innsbruck-Landeck-Bludenz, and for this purpose is to be extended by a generating set of 8000 horsepower. The Ruetz and Spullersee stations are to be connected by a 55,000-volt transmission line about 110 kilometers long. It is hoped that in 12 to 15 years all lines will be electrified.

Ammonia from Coal Distillation

The Significance of Recent German Experiments Looking to an Increased Yield

IN the year 1904, in a publication entitled "Coke Ovens and Their History" Dr. Paul J. Mallmann proved conclusively that the patents taken out by Otto, Hilgenstock and other German scientists for the distillation of coal and coal gases had been anticipated in the seventeenth and eighteenth centuries by English and Scotch scientists. What Otto and Hilgenstock did in the sixties and seventies of the last century, these British pioneers had thought out and patented at least a hundred years before; but unfortunately these British patents were permitted to lapse without in any way benefiting mankind. Between the years 1623 and 1868 practically all patents dealing with coal gas distillation bore British names, yet it appears that, with rare exceptions, not a single one was either exploited by the inventor himself or found financial support in England. Like Wm. Bessemer's discoveries—if for the time being we credit him with the discovery of the pneumatic principle and the pear-shaped furnace used by him for converting molten iron into steel—these had to go abroad to secure due recognition and financial support.

We are dealing again today with a German invention and practical application of discoveries made by British minds years before. In the year 1868 and again in the year 1874 J. C. Hills secured letters patent Nos. 1368 and 1934, respectively, to wash coal gas of its hydrogen sulfide contents, with a diluted ammonia solution, but it appears that Hills did not ascertain the precise temperature required at which the hydrogen sulfide contents of the gas is absorbed. According to his calculation six to seven times the quantity of ammonia was necessary for the elimination, whereas in fact double the quantity extracted from a ton of coal is sufficient to absorb all the hydrogen sulfide from coal. As J. G. O'Neill pointed out correctly in the year 1912, on page 868 of *Progressive Age*, it was due to this miscalculation that Hills' patent did not prove a commercial success.

Now O'Neill's process is in operation at the Gas Works at Geneva, in the State of New York, and due reference will be made to same in the course of this review. Here be it briefly stated that hydrogen sulfide, hydrogen cyanide, and some carbon dioxide are withdrawn from the coal gas by passing it through a weak solution of ammonia.

Generally speaking it has not been found to be a paying proposition, on account of the low prices paid for the commodity, to extract the hydrocyanic acid from coke-oven gas by installing the required cyanide washer, because the amount recovered is found to be insufficient even in the gas produced by the gas plant. It stands to reason that both to the by-product-recovery coke-oven plant and by inference to the gas plant, it would be a commercial advantage if that portion of the hydrocyanic acid now burned uselessly in the ovens could be cheaply converted into ammonia.

F. N. Sutton, in charge of the coke-oven plant of the Colliery Amalia at Werne, Westphalia, demonstrated in 1914 to the satisfaction of Carpenter and Linder, as is recorded in the *Journal of the Society of Chemical Industries*, page 584, Vol. 23, that the excess of ammonia gas was due to hydrocyanic acid occurring in the Claus furnace, which had been supplied with the off-gases of a gas-liquor utilization plant. There was shown a considerable excess in ammonia in the leaving gases over the entering gases, though the gas volume had been increased from 1 to 1½ by the air for combustion. The entering gases showed 1.955 grams of ammonia per cubic meter and the retiring gases 11.896 grams per 1.5 cubic meter; and Sutton argued correctly that this eightfold excess of ammonia could only be due to the presence of hydrocyanic acid, since the quantity of ammonia entering the furnace as a carbonate was far from sufficient to permit of any other explanation. Hydrocyanic acid forms ammonia with NaOH according to the equation

$$HCN + NaOH + H_2O = NH_3 + HCO_2\,Na;$$

and determination of the satiated gases as 20.149 grams and of the hydrocyanic acid as 12.739 grams per cubic meter showed that this quantity was quite sufficient to explain the ammonia formation. The correct conclusion was arrived at, that the ammonia was produced by the hydrocyanic acid and the gas vapors generated by the oxidation of hydrogen sulfide. Again it has been found that ammonia is produced when water vapors and hydrocyanic acid are conducted over catalyzers like chamotte iron oxides or weldon mud, if brought to a sufficiently high temperature; similar results were attained by Schreiber as narrated in the *Magazine of Applied Chemistry* of Nov. 8, 1912.

Profiting by these investigations Dr. Freidrich Sommer designed an installation which converts hydrocyanic acid into ammonia, thereby transferring a loss of the by-product-recovery coke-oven plant into a profit. The experiments conducted covered a considerable period of time, and are herewith briefly given in epitomized form, as well as a short description of the plant employed.

Hydrocyanic acid was liberated from a solution of potassium cyanide, the contents of which had been checked by volumetric analysis, by dripping sulfuric acid into a potassium solution. The hydrocyanic acid then liberated was heated with water vapors and led through three washing bottles. The best results were secured when sulfuric acid of 60 degrees Baumé was used. Twenty-five cubic centimeters of potassium cyanide solution, corresponding to 12.31 cubic centimeters of normal silver solution or equivalent to 24.7 cubic centimeters of normal ammonia, were brought to the boil with water in an Erlenmeyer, and then were decomposed by slowly adding through a dropping funnel 50 cubic centimeters of normal sulfuric acid. The hydrocyanic acid thus generated was led through 3 wash bottles each containing 25 cubic centimeters of sulfuric acid of 60 degrees Baumé. The hydrocyanic acid which was not changed into ammonia was collected in ammonia and liberated. The sulfuric acid contained in the wash bottles was diluted and the ammonia contents determined. The results of this test showed that an excess of water vapors and heating act favorably on the acid and up to 98.37 per cent of hydrocyanide was converted into ammonia. But since the hydrogen cyanide vapors when leaving the satiator are not only rarified with steam but also with carbon-dioxide gas, an experiment with an apparatus which could force a jet of carbon dioxide through the reaction vessels was made. The conversion into ammonia was slightly reduced, but was still satisfactory. By introducing the jet of carbon-dioxide slowly 95.95 per cent of the hydrogen cyanide was converted into ammonia, whereas by accelerating the flow of hydrocyanic acid the output in ammonia sank to 92.72 per cent.

The experiments were carried on with a large excess of steam, and the question arose whether a lesser steam content of the reaction mixture would advance or damage same. Consequently the further experiments that were carried on were conducted by satiating the gas at a temperature of 70 degrees Centigrade with steam, when it was conducted into the acid.

The generated hydrogen cyanide passed with the additionally introduced carbon-dioxide gas, and the vapors of water—corresponding to a satiation at the cooling temperature—through the three reaction bottles, where it was either dissolved or it passed with the carbon-dioxide gas into the enlargement tube, filled with ammonia, where the hydrocyanic acid not converted into ammonia was absorbed. The last wash bottle contained diluted sulfuric acid, so that the ammonia carried along from the spherical tube could be absorbed.

The dropping funnel was repeatedly rinsed out so that it

was certain that all potassium cyanide entered the decomposition flask. After the completion of the tests the absorbed non-decomposed hydrocyanic acid contained in the spherical tube was triturated with nitrate of silver, with potassium iodide as indicator; the contents of ammonia contained in the sulfuric acid was ascertained separately.

Experiment with carbon dioxide, also experiment with hydrogen addition gave good results; tests carried through at a low temperature of the reaction acid produced a large quantity of non-dissolved hydrogen cyanide, and even a loss, a finding which up to now had not appeared in any one of the previous examinations; further tests showed still greater losses in spite of higher reaction temperatures, and this proved that the loss was not due to a low reaction temperature. It was also found that the potassium cyanide solution had decomposed by forming cyanide combinations, and that it was impossible to generate from these combinations further hydrogen cyanide by adding diluted sulfuric acid.

As a consequence all other experiments were carried through with a new potassium cyanide solution; a very high conversion was attained without any loss, the speed of the gas being now measured by a gas meter. A gas meter of 28 liters' capacity was eventually added and the gas mixture for one test was found to be of the following composition by volume: Oxygen, 4.15; carbon dioxide, 8.45; methane, 2.55; hydrogen, 69.90; nitrogen, 14.95.

The experiments showed that a high output of ammonia could be obtained with the described installation, at a given temperature, and were now applied to an outfit adapted to the coke-oven by-product-recovery practice.

Of the direct processes, the one of Collins appeared the one most suited, for in this the hydrocyanic vapors emanating from the column apparatus enter the satiator independent of, and separated from the gas.

In the lowest plunger the vapors give up their ammonia contents and their excess of steam to the liquor, having given off a portion of their temperature to the inner partition, *i.e.*, the separation wall. The lye has a temperature of from 70° to 75 degrees Centigrade; in the four reaction chambers, the sulfuric acid meets the vapors having been raised by the vapors to a temperature of from 70 to 100 degrees, and converts the hydrocyanic acid into ammonia, bringing it to the lye bath. Even the old open satiators or the closed satiator of the Weldon type can be built into the hydrocyanic-acid recovery plant as an adjunct without any difficulty whatsoever.

It will be found profitable to increase the contents of the hydrocyanic acid found in the coke-oven gas water and Dr. Sommer achieves this end in the following manner:

He separates that portion of the vapors of the column apparatus emanating from the lower columns reserved for volatile ammonia, or alternatively separates the vapors of the lime column, eliminates the steam by means of a reflux cooler and conducts the ammonia vapors, practically free of CO_2 and H_2S, into the gas main before they enter the last cooler.

The small alteration required in the steam conduit of the separating plant makes itself well paid especially if dry coal is coked because the hydrogen sulfide and the hydrocyanic formations are materially increased and an increase in steam consumption does not take place.

A process to some extent similar to the one just described is the O'Neill process in operation at the Geneva Gas Works, at Geneva, N. Y. It tends however more to wash the gases of their hydrogen-sulfide contents and the process is mentioned in the year 1912 by the *Progressive Age*, on page 868, and by the *Journal for Gas Illumination*, on page 304 in the March issue of 1913.

It appears that this process increases considerably the steam consumption, and it would also appear that hydrogen-sulfide, carbon-dioxide and fixed ammonia are reintroduced into the gas water circulation—drawbacks which are avoided by introducing ammonia vapors from the lime columns; a procedure which does not demand an unnecessary steam consumption.

Hydrocyanic acid is recovered without difficulty by installing the satiator when dealing with old and indirect installations. And this is of particular importance to the gas works, for by so doing they obtain a considerable increase in their ammonia output on account of the relatively high cyanide contents of their gas water.

To establish this Dr. Sommer created similar conditions by leading a mixture of hydrocyanic acid and hydrogen gas into a three-necked bottle containing saturation lye, the temperature of which was kept at 70 degrees Centigrade by a thermostat before the mixture entered the flask holding the sulfuric acid, which was retained at a temperature of from 70 degrees to 100 degrees Centigrade. The liquor at 70 degrees Centigrade served here the purpose of a reflux cooler, since it absorbed the excess of steam; besides this, a strong current of air was forced through the lye, a procedure which corresponded with gas production practice, and carried with it also the steam.

Losses of hydrogen cyanide were sustained in some experiments because of the non-uniform pressure of the air entering and leaving, and also because of the flow of hydrogen cyanide mixed with hydrogen and steam, which could hardly ever, or only with great difficulty, be kept uniform. Consequently it could hardly be avoided, that temporarily hydrogen cyanide entered into the air chamber, through the central open dip pipe, open at the bottom; and this gave to the air passing through the air chamber its characteristic pungent smell.

Remarkable appeared the contents of carbon dioxide and methane in the gas of two experiments. It had to be ascertained whether this occurrence was due to the dissolution of the hydrocyanic acid, or to the hydrogen drawn from the steel container. The hydrogen of the supplying steel container was examined and was found to contain by volume hydrogen 95.65 per cent, oxygen 0.30, carbon monoxide 2.05, and nitrogen 2.00. Therefore, the methane could not have originated in the container. To eliminate the oxygen, the hydrogen gas was led through a porcelain tube, at a temperature of 1100 degrees Centigrade, and then led through liquor and soda lime to eliminate any possibly formed carbon-dioxide gas. Notwithstanding these precautions again methane was found; hence methane was formed during the reaction, namely, during the dissolution of formic acid, formed as intermediary product. To prove this assumption carbon monoxide was produced from formic acid. This gas was passed through soda lime to eliminate carbon-dioxide and acid vapors, and showed in analysis, by volume, methane, 2.05 per cent; hydrogen, 0.85; carbon monoxide, 94.10; oxygen, 0.60; and nitrogen, 2.40.

By this it is proved that methane can be generated in considerable quantities when formic acid is decomposed. This reaction will also take place in the method described, since the dissolution of hydrocyanic acid passes over the formic acid. The analysis of the experiments show carbon dioxide content. The hydrogen content of the carbon dioxide produced from the formic acid proved that formic acid is dissolved according to the following formula: $HCO.OH = CO_2\ H_2$.

The conditions of the experiments with hydrogen cyanide gas are quite similar, and in such a way the reaction takes place; only one does not find the generated hydrogen gas because hydrogen has been added; on the other hand the equivalent amount of carbon dioxide gas makes itself observed.

From the last tests it is apparent that in practice also where steam charged with potassium cyanide has to pass through a sour sulfate liquor, far-reaching disintegration must take place. But it was not proven whether or not hydrogen was generated when hydrocyanic acid is saponified. Furthermore, it had to be ascertained whether the constantly found hydrogen sulfite advances the reaction. Carbon dioxide and hydrogen sulfite were passed through the outfit and it was shown that over and above the previously proven carbon dioxide and methane, hydrogen was also produced in considerable quantities through secondary reactions.

Now the tests were made with an addition of hydrogen sulfite. Since hydrogen sulfite produced from ferric sulfites is never free of hydrogen, the attempt was made to produce the hydrogen sulfite by acetating poly-sulfide of potassium. As the production of this gas by these means was found to be too uncertain a stream of carbon dioxide gas was passed through a heated, or through a cold concentrated solution of potassium sulfide, and this stream of carbon dioxide gas satiated itself with from 5 to 2 volume per cent of potassium sulfide. In this experiment the washing flask was used for the poly-sulfide of potassium, and the tilting apparatus was utilized for the generation of the carbon dioxide gas. A thinly drawn out glass tube to act as capillary was inserted in sequence before the tilting apparatus, which arrangement regulated the speed of the gas in all subsequent experiments. In the flask there was contained, as in previous experiments. normal sulfuric acid, in the dripping funnels a potassium cyanide solution. The gas was collected in the gas tank and then forced through an apparatus to free it of carbon dioxide gas and hydrogen sulfide, which it contained in large quantities.

The wash bottles and the gas collecting tubes were filled with a strong lye of potash; besides this the gas-collecting tubes contained some ferro-hydroxide to eliminate by absorption any remnant hydrocyanic acid. By water pressure the gas was forced from the gas tank through the worm of the washing bottle; and the carbon-dioxide gas as well as the hydrogen sulfide gas were absorbed. The gases which had not been absorbed collected in the upper portion of the wash bottle and entered, forcing the potash lye (liquor) before it, the upper portion of the first gas-collecting tube. After they had filled this tube they entered the next gas-collecting tube. More than 750 cubic centimeters of gas were never collected, excepting in one experiment when about treble that amount of gas was found to be present.

Prior to the gas being liberated from its absorbable constituents, an average sample was taken from the gas tank to ascertain the relation of the absorbable portion to the non-absorbable portion in lye of potash (liquor). When the test had been completed and the gas after repeated washings had been collected in the gas tank, about 0.95 liters were led through a small aspirator through acetate of cadmium, and the hydrogen sulfide contents ascertained.

Experiments carried through with an addition of hydrogen sulfide show that this addition acts favorably on the ammonia output, in so far as it damps the secondary and harmful reactions, which take place under the formation of methane and hydrogen.

CONCLUSION

It is claimed that hydrogen cyanide without steam or labor can be recovered as sulfate of ammonia by saponification of the hydrogen cyanide by means of sulfuric acid. Considering that a major portion of this is lost at present, and the installation is not expensive, trials at the gas works and at by-product-recovery coke-oven plant are worth while, but first exhaustive tests on the lines indicated should be made in the laboratory, with a view of simplifying the procedure.

POROUS METALS FOR STORAGE BATTERY PLATES

For certain purposes, in particular for the construction of storage-battery plates, it is desirable to employ metal in a porous state, since in this condition there is a comparatively large surface for a given weight of the metal. This is achieved by means of technique based upon the fact that alloys in process of solidification crystallize differently according to the temperature at which the operation is conducted and do not solidify abruptly at a given temperature, but solidify slowly and between temperatures which are separated from each other by intervals varying in extent according to the metals and their proportions which enter into the alloy. It might perhaps be expected that each constituent metal would "freeze" out of the mixture completely as its solidification temperature is attained; but this is not the way it works. The thing can better be illustrated by an example than described in general terms.

In an alloy composed of equal weights of lead and antimony solidification begins at 540 degrees Centigrade by the formation of crystals of antimony whose dimensions increase in proportion as the temperature decreases down to about 225 degrees. At this instant the still fluid mass consists of an alloy which is very different in proportions from the initial mixture, since it contains 87 per cent of lead and only 13 per cent of antimony. This is called a "eutectic" alloy; and its critical temperature of +225 degrees represents at once the point of fusion and a constant temperature of solidification. As soon as this temperature is reached in the course of cooling one observes the instantaneous solidification into a mass of the entire remainder of the liquid, and the appearance of a tangle of fine crystals of the two metals. However, so long as the temperature remains between the two extremes of solidification, 540 and +225 degrees, the ensemble retains its plasticity, since the crystals of antimony are immersed in the eutectic liquid. At the end of the operation the mass is composed of a network of comparatively large crystals enclosing canals of various size and configuration, which are filled with the tangled and much finer crystals of the eutectic alloy.

A Danish metallurgist named Hanover has conceived the idea of preventing these latter crystals from forming merely by expelling the liquid portion before it has attained its solidification temperature; and his method has been found advantageous in industry. To eliminate the remaining liquid it is only necessary to employ a non-oxidizing gas under pressure—for example, either carbon dioxide or nitrogen. Oil pressure is available here, or better still the liquid is expelled by centrifugation. The final porosity is a result of course, of the spaces left in the canal which were previously filled with the eutectic alloy. The degree of vacuity depends on the one hand upon the proportion of the metals in the original mixture, and on the other upon the temperature at which the liquid is expelled. Consequently, the degree of porosity can be controlled to a considerable extent, care being taken merely that the metal finally obtained after evacuation of the canals shall be sufficiently solid.

In practice it has been found that the higher the fusion points of the metals employed, the greater the difficulty of obtaining porous alloys; but this difficulty can be avoided by using the method outlined to obtain first a porous mass of lead, for instance, the spaces in which are then filled with metals which are not very fusible, such as copper, silver, etc. These are to be deposited by electrolytic means, and then the temperature can be raised to a point slightly above that of the fusion of lead, and the latter can be immediately expelled by centrifugation as soon as it becomes liquid. In this manner we obtain a porous mass whose cavities correspond to the solid portions of the previous mass and vice versa—in short, we have a sort of negative of the original porous mass.

By this ingenious method of operation the available surface of the sheets of lead can be made a hundredfold as great instead of scarcely tenfold as great as when the usual methods of undulation and perforation are employed. Thus the capacity of battery plates is very greatly increased, aside from the fact that it remains possible to increase the surface still more by the usual means of employing metallic oxide. It is only necessary in fact, to employe these substances to fill the cavities left by the expulsion of the eutectic alloys. However, since it is necessary to have a solid support to prevent the deformation of the crystallized mass upon the expulsion of the liquid portions, a piece of metal cloth is employed to hold the mass against a grating during the process of centrifugation.

The porosity of the plates thus obtained is so great that after they have been soaked in water, the latter can be entirely expelled by placing the mouth close to one side and blowing vigorously. In short, these plates are actual metal sponges.

EXHIBIT FROM PRIVATE MARKET GARDEN AT FAIRBANKS, SHOWING THAT ALASKA IS NOT ALL SNOW AND ICE

Uncle Sam's Last Free Lands

The Role of the Cow and the Plow in Interior Alaska

By J. Paul Heritage

FIFTY years ago men predicted that our free lands would last five hundred years. Such a comment did not consider our great railroad development and heavy immigration. Now if the soldier gets a farm he will usually receive cut-over lands, or swamp areas recently drained. Since the early nineties, the demand for free lands has threatened the supply. The corn belt farmer, when farm values climbed, went to free lands in Canada, our own semi-arid region in the West, or came back to the abandoned, almost free farms in the East and in New England. Unless we intensify greatly, drain or irrigate vast areas, we will soon need new lands.

Uncle Sam has a lot of free land for his sturdy sons who possess the same pioneer spirit which pushed across the Appalachians into the fertile prairies of the middle West, up into cold, glaciated Wisconsin and Minnesota, and now on into dry farming sections about the one hundredth meridian. It is to Alaska that the free land farmer must look.

Alaska is called our Arctic province, but is three-quarters in the Temperate Zone. Secretary Seward, who urged the purchase of this territory, was severely criticized and the area was dubbed Seward's "Icebergia" and "Refrigerator." In 1898 discoveries of gold in the Klondyke and at Nome made folks think Seward had been very wise, and Alaska was thought to be a mine of wealth. It is not, however, an iceberg, nor is it an Eldorado.

In latitude it is the exact counterpart of the Scandinavian Lands, which contain nearly 8,000,000 people, as compared to Alaska's less than 75,000. Pan-handle Alaska enjoys climate similar to the State of Washington, which is so highly praised by Dr. Ellsworth Huntington, in his "Civilization and Climate." This area has abundant rainfall (100 inches). Interior Alaska along the Yukon and its big branch, the Tanana, has less rainfall (25-30 inches), but generally sufficient for a cold climate, which has scanty evaporation. The winters are rigorous, but not much more severe than those of Dakota and Montana.

The common idea is that such northern climes are unproductive agriculturally. Interior Alaska, however, has one great advantage given her by nature. This is the long days of summer. The great amount of sunlight and the absence of many cloudy days are a God-send to northern areas like this, and make agriculture possible. Many places have luxuriant vegetation as the illustrations show. The vegetable seems at home in this clime. The white potato is the king of northern crops. It will grow in the southland but it seems to thrive in the climate of cool nights and not too hot days. It does not demand a long season. Turnips and cabbage are rivals for second honors. Peas, tomatoes, radishes, lettuce and cauliflower are among the familiar products. Foreign plants such as the rutabaga, a Swedish turnip, and Swiss chard, are good.

The Experiment Stations at Rampart and Fairbanks urged the growth of potatoes for some years. In 1911 they had made a little impression on those whom they were urging. In that year there were said to be 1000 tons of potatoes shipped into Fairbanks from the Puget Sound District. Since that time, however, there has been response to the suggestions until the district faces the bogey of all vegetable growers—over-production. Perhaps Alaska will solve this problem by using the potato to make alcohol for gas engines. There is no thought of doing this at present, however, and without adequate transportation facilities, Fairbanks must feed its surplus spuds to the pigs. In 1911 the tubers brought $12 per bushel. At recent prices, $1.67 per bushel, they are no bonanza. In fact, with teams at $12.50 per day, it probably does not pay. This applies only to the Fairbanks area, however, where the excellence of the conditions seemed to have spurred the development beyond normal.

Some 900 tons were raised in the Fairbanks district at last report, and one-third were raised within two miles of the station. The Experiment Station having convinced the farmers that potatoes could be grown, reduced its acreage and now disposes of the seed, or feeds them to the pigs. The Government authorities do not desire to compete with the growers. The Station will continue the growth of the potato, however, since it reiterates that it considers the cultivation of this plant the equivalent of a summer fallow, a practice which otherwise would be necessary.

The Stations have, on small plats, grown at the rate of 700 to 900 bushels to the acre. On five acres they averaged 200 to the acre. Larger areas averaged 150. One farmer, in 1914, reported 230 bushels as the average for a 7-acre field, and on a small place he got at the rate of 330. It is not to be expected that yields would always be nearly this high, but it is given to show that they can be grown and apparently about as well as anywhere in the country.

The argument for the potato is well summarized by one agricultural report, which says "The potato is by long odds the most important item in the people's diet. Everybody uses it, everybody knows how to grow it, and, with proper care, it can be grown all over the territory." This is rather flowery for an Experiment Station report, but it is the opinion based on considerable evidence. Rampart, where some of the records are taken, is 300 miles north of Petrograd, Stockholm, and

Christiana, and parallel with the central part of Iceland. Norway and Sweden grow potatoes as well as other crops in areas comparable to these.

It is a generally accepted principle that northern grown seed is hardy and quick maturing, and therefore desirable for use in southern climes. Hence Aroostock County, Maine's most northern section, is the greatest potato seed section in North America. Transportation of such bulky product would be a handicap in Alaska, in this respect, but what about turnip and cabbage seed? The turnip is a plant which the Northerners are willing to back against any grown in the South. These roots also have value as human food as well as food for hogs. The various root crops thrive well in this region and offer great possibilities for the future.

Some consider cabbage next to the potato. In 1911, Puget Sound cabbage was said to be found in every grocery store in the territory. Some progress has been made in eliminating this useless transportation. One farmer claims to have sold sixteen tons of cabbage from a half acre. At this rate, overproduction will become a factor in this product.

As to the success of vegetables, an actual grower says "Lettuce always does well. Cauliflower is the finest I have ever seen or tasted. Swiss chard was tried for the first time, and was very fine. It can be cut about every ten days." Another farmer says "I had a splendid crop last year. I had four acres under cultivation, and I raised about 300 sacks of turnips, about 100 sacks of rutabagas, 150 sacks of potatoes, and about 100 pounds of cabbage. I also raised eight Hubbard squash, weighing 16 pounds each, that were also ripe." A third man raised 1000 head of cabbage, much better than those he had raised in Washington, and raised 5 tons of potatoes which he characterizes as the finest he ever saw.

So far it seems that forage crops do not thrive as well as vegetables. They require a longer season, and if perennial, are likely to be all or partly winter killed. The Experiment Stations have been doing yeoman work on this problem. It is a painstaking task and requires years to demonstrate effectively. Alfalfa, the crop mainstay of many an area, is much desired for this region, and the work so far has been fairly encouraging. Rampart had announced it a sure success, but in the winter of 1914-15, it was winter killed. It is hit heavily when snow is off the ground in spring. The Siberian alfalfa bloomed, but did not seed, therefore could not perpetuate itself. Some fourteen varieties are being grown, with the desire to get one that is hardy, yet retains the yielding qualities. It is claimed that even if it has to be sown every spring, it is of probable value for hay that year, with its value as a legume thrown in. Nitrogen is an element sadly lacking in this soil, or if present, is unavailable.

The Experiment Stations object that they have not yet been able to give alfalfa a perfectly fair trial in this northern section. The plants had to be brought from Sitka, a journey of 2000 miles, which long journey caused them to arrive in a poor condition. Much work will be done with alfalfa, for the worth of this plant is so great that it will not be easily given up. If alfalfa should fail, as seems unlikely, vetch may be its substitute. Clover, a legume, is unable to survive the winter, according to several experiments.

Hay has been imported from the United States at great cost. This seems inexcusable. Native grasses abound in many areas and make excellent silage. Oat hay can be grown most anywhere, although timothy has been a disappointment. It has frequently been too thin to cut.

The grains are exceedingly important for man and animals and progress has been made in growing them on a fairly large scale. Barley is thought to be the best grain for the area. This grain, at home as well as in the Mediterranean climate, thrives even above the Arctic Circle. It is thought that it will answer the needs of man as well as those of animals, should the more popular wheat fail. Barley, while containing less gluten than wheat or rye, is nevertheless the grain food of quite a portion of the people of North Europe, as well as many desert peoples. It also serves as a substitute for corn as animal food. It is possible that the absence of gluten may be partly solved by plant breeding. Hybridization has already approached a successful beardless variety of barley which will make it much better as animal food. Some twenty varieties are being grown and the yield has been as high as forty bushels to the acre.

Oats and rye are also being grown. Finnish Black Oats in 1915 were reported as growing forty-two bushels to the acre. Two years previously, twenty-five acres were cut for hay. Nine varieties have been grown and all ripened. Oats are much used in Norway and Sweden and seem to thrive well in Alaska. Rye usually ripens without serious damage. It had been supposed to be an absolute success, but, like alfalfa, it was hard hit in 1914, when only half a crop survived.

Wheat has been the object of much attention. Winter wheat has not fared well. Kharkov wheat was imported from Russia, but this needs some two and a half feet of snow as a protecting cover. Alternate freezing and thawing in spring are generally disastrous to wheat. In one year but twenty-five per

A STAND OF RYE AT THE RAMPART EXPERIMENT STATION

OATS AND BARLEY (*LEFT*) AND RUSSIAN SPRING WHEAT (*RIGHT*) AS GROWN AT THE FAIRBANKS EXPERIMENT STATION

cent survived. It also gets too heavy rains in August. It was announced in a recent report (1913) "that no winter wheat hardy enough had been found."

Spring wheat is up against the possibility of frost in August or September which would prevent its ripening. Nevertheless, for most of the interior, spring wheat is doubtless better than winter. It has survived some cool waves in August. The last report shows that a crop of forty bushels to the acre has been raised. Buckwheat has been considered a probable grain, although this has been frost nipped.

The situation may be said to be encouraging as far as grain, hay and legumes are concerned and further experimentation bids fair to make success more certain. These crops suggest animal industries since in most places these products are fed in large quantities to animals. Before entering a discussion of this problem, let us review the limiting factors affecting agriculture and therefore indirectly, animal industries. Among them might be mentioned the following:

1. *Climate.*—The severity of the climate calls the pioneer, the man whose wife and family are willing to bear conditions on the frontier. Here they may get a homestead tract if they are willing to endure the hardships incident to the pioneer life. The lack of rainfall may necessitate some irrigation in the interior, although the small evaporation is an offset to this. Particularly, there must be an intelligent selection of crops adapted to the temperature and soil conditions, following the lead of the experiment stations.

2. *Soil.*—Frozen for seven months it has no chance for chemical change. Thus a crop every other year is equivalent to one yearly in warmer climates as far as soil action is concerned. The ground needs fertilizer. If imported, this doubles the price on account of expensive transportation and makes its use, except in small quantities, prohibitive. Fish refuse and sea-weed may help solve the problem, and if animals are kept they will aid.

3. *Limited Market.*—Once the local market is supplied what then? Will the population increase? There will be much further mining, fishing and trapping, no doubt, and forests will be utilized. These industries will make additional markets. Transportation will probably for a long time prevent the shipping out of agricultural products of bulk, although the Government railroad from Fairbanks to the south coast should be a great aid.

4. *Labor.*—The farmer must bid against the mines for labor; and even under Alaskan prices, he can scarcely afford to do it. He finds it difficult to attract the laborer who has come for the conquest of gold and settle him down to the more prosaic occupation of farming. The native may finally be of some use in this respect as soon as he finds there are goods he desires beyond those of primitive times.

As to the inherent possibilities of animal industry, there are few cattle or hogs in central or northern Alaska. The Experiment Stations are continually asking for an appropriation to import Siberian yak. It is proposed to breed this animal with the Galloway cattle, a Scottish breed now being raised on Kodiak Island. This breed of cattle is small, and cannot get larger on native grasses. With grain, they should grow. The yak is a sure footed animal. He supplies raiment for the Siberians and even drags their plows. The cow gives milk capable of being made into butter—a merit which that of the otherwise virtuous reindeer does not possess. In Thibet the yak is used for transportation. Its flesh is good meat. The animal seeks its own food, does not fear the cold, in fact, is content to lie in the snow or swim in cold lakes.

TYPICAL ALASKAN-GROWN VEGETABLES: THE POTATOES FROM FAIRBANKS, THE CELERY FROM SITKA

A discussion of grains proves that the feeding of cattle can be solved. Farmers near Fairbanks are going into the industry. One has forty-five cattle, and he is eloquent in praises of the Yukon meadows. One of the interior stations reports wintering thirty cattle, feeding them on native grasses, red-top hay, yellow turnips and silage. Occasionally, steers are driven across the country to be fattened in this vicinity. Potatoes are excellent feed for these animals. Root crops are also advantageous. Two or three farmers were raising hogs near Fairbanks in 1914. Until feed is raised easily, they will scarcely pay at present prices. The animals must be protected from the cold by artificial heat. Full blooded animals are kept by the Experiment Station to sell to the farmers.

Sheep and goats would seem adapted to parts of Alaska. Sheep are raised somewhat at Kodiak Island to the south, but have not been attempted much in the northern sections where the rainfall is insufficient to give good pastures. Exportation of hides, a product of high value and small bulk, should be an important one for an area short on transportation facilities. The new Government road from Fairbanks to the south coast should be a great help in solving this problem.

A hotel 100 miles from Fairbanks had just burned down when the great traveler, Frank G. Carpenter, saw it. Reports to him said that this hostelry had kept 650 hens, 50 ducks, 70 pigs, 25 horses and 8 cows. Not many years before it was reported that some 60,000 cases of eggs were shipped from Seattle to Fairbanks alone, one-quarter of them being hauled over the ice at great expense. They were sold as high as two dollars per dozen, and the local ranch eggs were considerably higher. Bishop Rowe, who has traveled through much of this area, reports eggs as selling at a dollar apiece. The poultry industry would seem to have possibilities there.

Dairying is being tried on Kodiak Island and seems possible of extension. The Galloway cattle are supposed to be the best for such climes; Alaska in its southern part has great possibilities in this respect as Scotland, Norway and Sweden are prominent in them, and Danish butter is known all over the world. The interior has inferior pasturage, less rainfall and on account of the intense cold, would be a less attractive place for extensive animal raising. Two dairy herds were kept at Fairbanks in 1914. The winters are admittedly trying on the Galloways. It is for this reason that the yak is desired. Milk was sold by the farmers at 50 cents per quart.

The fur industry is an old one and while others have long since surpassed it, yet it is of importance, as over a million dollars' worth of furs are got yearly. In its influence on the people, it is small, and its future does not appear great. Instead of chasing the animals through the forests or setting traps in their haunts, the modern scheme is to raise them in your own back yard. There are ten or twelve fox farms in the territory. One at Copper Center is typical of what is done or what can be done in other places. At this farm there were in 1916 some two hundred foxes, three of which were sold for $10,000 apiece. The farm at Baker Hot Springs which is located on the Tanana River, near where it joins the Yukon, has paid as high as $15,000 apiece to the Indians for black fox pups. One farm has a capitalization of $300,000. Judge Moran has a farm on the Kobuk, and he says foxes are as easy to raise as cattle and hogs. He thinks the industry has brilliant prospects. Canadians are said to have sold silver foxes for as high as $25,000 a pair.

Many fur animals are diminishing, but the muskrat is a fellow who has held his own. He multiplies more rapidly than others. His fur is valuable and many claim he is excellent as meat. It may be that selective breeding will be introduced so that this industry will soon be removed from the trapping stage to the farm.

The reindeer industry is one of great moment to the natives, who use it for transportation, food and clothing. It saved their lives when their food supply was threatened. As a factor in our own meat supply, it has possibilities, and reindeer flesh is already being imported. The American cousin of the reindeer, the caribou, had never been domesticated, so the importation of the real reindeer had early been considered. In 1851 Prof. S. F. Baird advocated the move. Nothing definite was accomplished until nearly 1890, when Dr. Sheldon Jackson, a minister, who was General Educational Agent in Alaska, became much enthused over the project. After many discouragements, finally, Congress was persuaded to act. Dr. Jackson was assailed by the newspapers which accused him of endeavoring to make way with the public funds, and one Grand Jury threatened to indict him. Having a large amount of stick-to-it-iveness, however, he won out, and in 1891, with the aid of his assistant, Mr. W. T. Loop, prepared to bring in the animals. Sixteen were landed the following year. The work has proceeded under the auspices of the Department and the Missions to a most successful outcome.

Dr. Jackson saw that with the disappearance of the whaling industry, the introduction of fire arms, with their destructive effect on game, and the reduction of good fishing, the natives were headed for starvation. He reasoned, with abundant good sense, that it would cost the Government many millions to feed these people but it would cost only a few thousand to teach them to support themselves. This he knew was the only method which would instill self-respect and insure against pauperism.

The experiment was a risk. None in Alaska knew much about the details of management. Siberians and Laplanders had to be imported as instructors and there were various problems incident to the introduction of both man and animal. Chief among the expected difficulties was bothering by dogs.

POTATO FIELD AT THE FAIRBANKS STATION (*LEFT*) AND PART OF A CABBAGE CROP AT SKAGWAY

These animals infest Alaskan ports but their annoyance to the deer proved largely fictional, certainly nothing to be compared with the damage the canine does to sheep in this country. Wolves caused some stampeding, there was trouble at the birth of the animals, some died on the journey before food could be obtained, an interpreter was hard to secure, and the Siberians did not take kindly to the enterprise, fearing they would lose the trading of their deer skins for the oils which they desired from the Alaskans. All of these difficulties were solved, although they were of no small amount.

In 1917 there were at least 100,000 deer in the territory. The increase is largely the natural one since importation was stopped in ten years by the Russian Government, after only 1200 had been secured. In a recent year, 13,000 were killed locally for meat and skins. It has been estimated that at the present rate of increase the number in 1925 should be 800,000 and 1930 should be 3,000,000. These estimates are based on the fact that the number doubles every two or three years. New stations are being added from time to time, and the entire Arctic Tundra, as well as a large share of the Yukon basin, contains the valuable moss on which the deer makes its meals.

The animal is docile and affectionate. He does not try to use his horns on the attendants. Full grown at three years, he is then between four and five feet in height, and seven feet in length—from nose to tail. The usual weight is 250 pounds. The horns measure two and one-half feet from tip to tip. He is broken in harness at two years of age and this procedure, as with horses, is not entirely without excitement.

The reindeer has proven a god-send to the natives. Instead of their scanty provisions they can now have delicious steak, and if they follow the example of the Lapps they will eat every scrap of meat available. The doe gives milk suitable for drinking, if diluted, and capable of being made into cheese, but not butter. That the Eskimo has not availed himself of the milk to a marked degree does not detract from the probable use for the future. The animal furnishes shoes, boots and clothing—reindeer coats having been imported by the natives before the industry developed locally. The sinews are spun into thread and the antlers are made into various household ornaments and utensils. Whatever is left is manufactured into glue or boiled into soap for dogs. This equals the story of the pig which is all utilized except the squeal.

The service of the deer as a transporter is in some ways the most notable. Getting the food from moss relieves him of the necessity of carrying his provender. The dog, on long journeys, cannot carry enough food for his own needs. One man can manage a team of reindeer, whereas it is customary for a dog team, composed of several animals, to have two masters. The deer will outdistance the dogs, traveling 100 miles or more a day, if necessary, although it is inadvisable to attempt more than thirty on a long journey. He will go eighteen to twenty miles an hour for short distances, but should not be driven in excess of twelve for long periods. One pair is said to have hauled 1600 pounds. Here again, of course, the amount for a long journey would have to be a small fraction of such a record. The reindeer have been used to carry the mails, to carry soldiers, and have gone on rescuing expeditions of several hundred miles, as the one to Point Barrow years ago, when the natives were at the point of starvation.

Deserving natives are given deer after serving an apprenticeship with the Siberian or Lapp trainers. At the end of one year a native is given two animals, the second year five and at the end of the fourth, thirty-six. The girl who gets a "reindeer husband" is the envy of her friends. The Lapps say three hundred deer will support a family. Many in Alaska have that number; some Lapps in the homeland have five thousand to ten thousand. It has been wisely provided that the natives cannot sell their female deer, thereby keeping the white man from absorbing the industry. Lapp trainers receive the deer as part pay for their services and they may sell. In this way white men have acquired some. One company on the Seward Peninsula is said to own twelve thousand. The Missions were given deer to be returned at the end of six years, the Missions to keep the increase.

Commercializing this industry has been difficult for the white man. This is in part due to a fundamental difference in purpose. The white man in business wants the Eskimo to develop the reindeer, whereas the Department of Education introduced the reindeer to develop the Eskimo. Another observation is that the native is disinclined to work for the white man, but does well for himself. Unless the family aids, the job of tending the flock is generally one of twenty-four hours daily, requiring duty in blinding blizzards and Arctic temperatures. This does not appeal to the white man with his eight-hour day in a heated factory.

As our country becomes more populous it is natural that we will follow the Orient and Europe and reduce our meat consumption. This rule would be violated only if we could secure a supply from outside sources at a low price. Will the reindeer ever become a factor in our meat supply? In the present, no, but in ten to twenty-five years the answer seems much more likely to be in the affirmative. There is now, according to estimates, an area six to eight times that of New York State, unsuitable for agriculture but with rich pasture for deer. This area should support 10,000,000 reindeer. When it is considered that cattle of all kinds in this country in 1914 numbered about 55,000,000, the potentialities of the new industry are apparent. The possibility of such a number in two decades presumes no ruthless destruction. So far, only the excess males are killed.

Lapland sends 22,000 to market annually. Norway and Sweden exported the meat and smoked tongues to Panama during the construction of the canal there. The first shipment from Alaska left for Seattle in 1911. One hundred and twenty-five carcasses, totaling nine tons, were sold, some cuts as cheap as twenty cents a pound. Shipment was not permitted until there was a sufficient supply for the natives in the home districts. One writer saw a thousand deer ready for the butcher in 1916, and fifteen hundred was the amount set for 1917. This author, who has had world-wide observation, thinks venison will become as common as beef and mutton, and will be shipped to every town in the country. Recently it has been claimed by others that extensive exportation of the deer is mythical.

There is little doubt that it can be sent to our Pacific ports. The populous market, however, is in the East. This would involve an additional 3000 mile rail journey, unless the route by Panama were used. As to whether this market is to be reached, possibly we have a fairly analogous case in the beef raised on our western plains which is shipped to Chicago in great quantities to be slaughtered there for world shipment. It may happen that the price of beef will be prevented from its upward soar through fear of this competition. Canada could aid much in raising these animals. Dr. Grenfell purchased a few for Labrador some years ago, but they have been lost sight of in the other famous enterprises with which his name has been associated.

One of the limiting factors for further growth is said to be the amount of moss available. After the 10,000,000 limit is reached, there is still the possibility of feeding the animals. Experiments have shown that it can be done, but if it becomes necessary to buy feed, the great favorable point, free provender, will be gone. Forest fires are also said to threaten the life of the moss. Another limiting factor is the ignorance of the natives. They are more scared of a new idea than our most reactionary politicians. It is said that our cattlemen and breeders could secure more rapid increase of the animals if they would direct the enterprise. Introduction of caribou blood is thought to be a probability for the near future. The quantity of milk given, now about a tea-cup full, could probably be increased. Witness the breeding that makes a cow commonly give twenty or thirty quarts daily whereas in olden times she barely gave enough to support her own calf. Hoof

rot and hoof diseases are troubles which in time may require considerable expert advice.

For the pioneer, Alaska offers more abundant opportunity. The future of this area lies not with the miner, but with the farmer and the herdsman. Gold and coal and copper will be exhausted, but agriculture, if scientific, will go on forever. The experience of China, where farms have been successfully tilled for forty centuries, is illustrative of the fact that this industry is the enduring one. Alaska calls for settlers while her lands are free.

GRAPE SEED OILS

By E. Klinger

Very little is found in the technical literature concerning the oil that is extracted from the seeds of grapes. Only a few facts regarding the analytical constants of the oil are given in the standard reference books (*cf.* Lewkowitsch).

Grape seed oil has a specific gravity of 0.9202 to 0.9561, a saponification number of 178 to 179 and an iodine number of 94 to 96.2 according to Lewkowitsch. Because of its partial solubility in alcohol it is classed together with castor oil and because of its low iodine number, it is considered as a non-drying oil. However, information from various localities in Spain, where the oil is used largely, served to indicate that it was mixed with linseed oil or else used alone in making paints. This appeared to be in direct contradiction of the data published on this oil, and because of the importance of this product as a possible substitute for the more expensive linseed oil, a thorough large scale investigation of the properties of the oil and its applications was undertaken.

General Physical and Chemical Properties

The oil was light yellow in color, clear and had a pleasant vinous odor. The specific gravity was found to be 0.95. the saponification number 191 and the iodine number 130.5. The fatty acid was isolated from the oil and its saponification number was found to be 199.5, iodine number 133.5, melting point 23 to 25 deg. Cent. and solidification point 18 to 20 deg. Cent. All these analytical results were checked several times. The high iodine number indicates at once that the oil is a drying oil or at least a semi-drying oil. In this respect it is much like poppy seed oil or sunflower seed oil. Tests were undertaken to determine just how good a drying oil it was.

It was found that crude grape seed oil dried in four days but gave a very sticky film. Even after the coating of oil had remained exposed for a long time, it did not lose its stickiness. The absorption of oxygen by the oil was 7 per cent in four days in comparison with 14.7 per cent in the case of linseed oil during the same period of time. A grape seed oil varnish, made with 5 per cent lead manganese resinate at 180 deg. Cent. dried quite rapidly, but gave a very sticky film just as in the first case.

Other grape seed oil varnishes, prepared with different lead, manganese and cobalt salts, gave similar results. The cobalt salts had the property of causing the oil to dry more quickly than any of the other salts. In every case the coating of varnish was sticky after it had dried.

Applications

Further tests indicated, however, that when the oil was used in conjunction with a certain proportion of cling wood oil very good results were obtained. The oil is recommended for use in this manner as it gives just as good results as straight linseed oil and is much cheaper, which makes the paint or varnish cheaper as well. The mixture of wood oil and grape seed oil contained 2 parts of the former and 1 part of the latter. It was heated to 180 deg. Cent. and mixed with 4 per cent of lead manganese resinate. The varnish gave a faultless coat with a lacquer-like finish and was not sticky after it had dried out. The oil may be used with linseed oil in the proportion of one to two, one to one or two to one in making varnishes for use in painting where it is not important that the varnished surface remains sticky. The china wood oil and grape seed oil varnish is very efficient for varnishing floors and for other decorative purposes.

It was also found that when the grape seed oil was heated for a long time it polymerized slightly. Heated at 290 to 300 deg. Cent. for 1½ hours it became very viscous and after two hours it could be drawn out into strings. Shortly afterward the contents of the vessel solidified into a rubber-like mass, which exhibited linoxyd properties after cooling. In comparison with linseed oil, the polymerization took place much more quickly. This would suggest a possible use for the oil in the manufacture of oilcloth, etc.—E. Klinger, *Farben Zeitung*, 26, 6.

GENELITE

A new material known as genelite has been developed to serve as a self-lubricating bearing metal. It is a high grade synthetic bronze, containing 40 per cent graphite by volume in the July number of *Mining and Metallurgy* and the Scientific American for June 11 the following particulars are given:

Tests have shown a high degree of porosity, the metal being able to absorb as much as 2½ per cent by weight of oil. This characteristic is made use of in high-speed applications, where oil is applied to the outside of the bushing and carried through to the bearing surface by capillary attraction. Another characteristic is that the bearing never seizes or freezes, or, the metals of the shaft and the bearing never flow or weld together. If a bearing sticks, owing to too close a fit, all that is necessary is to reassemble it with the proper fit, no damage being done to the shaft or bearing.

Among the self-lubricating uses for the new bearing are brakerod bushings, clutch centering bushings, throttle control, fan- and pump-shaft bushings, where such material saves much trouble and expense of overhauling and repair. On the main engine, genelite has proved useful for places such as main bearings, crankpin bearings and piston-pin bushings which are supposed to be well lubricated at all times, but where wear is likely to be excessive due to the oil losing its lubricating value from dilution by unconsumed fuel, or insufficient oil.

Genelite is made from the oxides of tin, lead, and copper, composing a high-grade bronze, plus graphite, all the materials being in a finely divided state. Graphite is added in sufficient excess quantity to reduce the oxides to the metals and leave the required graphite content in the finished material. The oxides are partly reduced by heating the mixture. The mixture, still in powdered form, is then pressed as nearly as possible to the required shape in massive metal molds. In this pressed form it will not stand much rough handling, so it is given a final bake, which sinters the metals together into a homogeneous bronze, holding the graphite uniformly distributed throughout its mass. The baking serves to clamp the graphite particles securely within the mass of bronze, so that they cannot be washed out or detached save by dissolving away the surrounding metal with acids.

The material has the general appearance and body of bronze, but the characteristics are different. It does not machine readily by the ordinary methods, but can easily be ground, which has been found to be the best method of handling it in quantity. Neither has it the physical characteristics of bronze, having very low tensile strength, but withstanding high compressive strains.

When considering the relative performance of bearings, all the factors entering should be given due consideration. A self-lubricating bearing should never be compared with a lubricated one, for no bearing will give as good results unlubricated as a similar bearing properly lubricated. But it is sometimes necessary, due to inaccessibility of parts, or neglect on the part of the user, to install bearings that are self-lubricated. In such places genelite is in a class by itself.

The Oldest Plants in the World*

The Psilophytes: A Newly Discovered Class of Fossil Plants of Remotely Ancient Origin

The rock-borne records of archaic flora are by no means so complete as those of the primeval fauna of the world, which is natural enough considering the fragility of the originals. Consequently, botanists all over the world are rejoicing in the comparatively recent discovery of some admirably preserved petrified plants belonging to an extremely remote geological era, probably the Lower, certainly not later than the Middle, Devonian. While this important discovery was made in 1913, it is only very lately that the silicified plants have been described by the paleo-botanists in charge of the work, Dr. Kidston and Professor Lang, whose studies in fact are still unfinished. The deposits were found in a bed of chert in Aberdeenshire, Scotland, by Dr. Mackie of Elgin. The plants formed beds of peat mingled with layers of sand, an arrangement which indicates a succession of turfy layers of soil, covered with colonies of plants, and subject to inundation from time to time. The whole series was finally covered with water containing silica.

These ancient peat bogs have already thrown much light on various vexed problems and fruitful discoveries are still expected by those in the progress of the work. The accompanying article from the pen of the French scientist, Leon Bertin, furnishes an excellent idea of the three genera of plants already described, the Rhynia named from the locality, Rhynie; Hornea from Dr. Horn, a former director of the Geological Survey of Scotland, and the Asteroxylon.

A specially interesting point is the comparison suggested between these plants and certain red algæ. This fact is regarded by some authorities as lending some color to a theory recently propounded by Dr. Church of Oxford, who expresses the view that at the very dawn of geological history, the earth was entirely covered with water, and that from this (ionized salt) water life was evoked by the energy of the sun. This first phase of plant life was, of course, plankton, but as portions of the earth's crust were forced upward from internal strains, certain areas of the bed of the sea came near enough to the surface to make it necessary for these small organisms to adapt themselves to the new conditions. From the encysted flagellates floating in the water, there developed, according to Dr. Church, plants anchored to one spot. He is of the opinion, furthermore, that this condition lasted for millions of years, during which time these anchored plants became highly complex in structure—far more so, indeed, than any seaweeds of the present time. Finally, a third phase was entered when the land emerged from the sea, so that the ocean dwellers were obliged perforce to become land dwellers or else perish. If this view is correct then, to use Dr. Church's expression, "The beginnings of botany are in the sea." The picture drawn by Dr. Church is very different from that imagined by some geologists who take us back to an era when the rocky crust was bare of all vegetation. The bearing of this upon the present paper is obvious.—The Editor.

A GREAT many persons have demanded of me an answer to the very naïve question: *Where does such and such an animal or such and such a plant come from?* The problem of the origin of things has profoundly impressed their minds—for this problem is buried in shadow and in mystery. However, it is not worth while to try to solve it by means of more or less fantastic hypotheses. . . . It is certainly better to say frankly that one is unable to answer a question than to simulate even a rudimentary amount of knowledge. For this reason it becomes us to exhibit extreme prudence with respect to the origin of the plants which adorn our globe. In spite of the really immense progress made during the last half century in the science of Paleobotany, *i.e.*, the science of fossil plants, or rather of those petrified remains of them which have been preserved in various strata of the earth's crust, we are still far from being able to give a complete and definite answer to the question regarding the form in which the vegetable kingdom had its birth.

What were the first plants in existence? The answer is lost in the abyss of time, and it would appear that there is no fossil which has been capable of preserving these original habitants of the earth.

The oldest *known* terrestrial plants belong to the Devonian period; all of the previous geological epochs, *i.e.*, the Silurian, the Cambrian and the pre-Cambrian appear to be lacking entirely in fossil plants. Beginning with the Devonian, on the contrary, the continental floras underwent a prodigious development down to the Carboniferous age, the exuberance of whose vegetation is borne witness to in the deposits of soft coal and anthracite in various parts of the earth's crust, since these deposits, as a matter of fact, consist of plant débris. Without entering here into details as to the form of the Carboniferous age, we may state its principal elements as follows:

1. The ferns.
2. Horse-tails, similar to the horse-tail which grows in our own times in marshy meadows and woods; these plants possess non-branching stems bearing at regular distances rings or whorls of small leaves.
3. Lycopods; these are plants of a kind at present confined to mountainous regions, but especially abundant like mosses with us, in tropical forests. The stalks and roots of the lycopod are branched in successive forks and their branches are covered with scales.

It is necessary to add that the ferns, the horse-tails and the lycopods of the Carboniferous age, instead of being comparatively small, as at the present time, were all *arborescent* or tree-like in nature, attaining a height of from 30 to 40 meters.

When we pass from the Carboniferous to the Upper Devonian, we find that the flora, though more restricted in character, being less rich both in individuals and in species, is still capable of being described in terms such as apply to the plants of our own time. It contains in particular the gigantic arborescent fern, known as the *Archaeopteris Hibernica* found in the southeast part of Ireland, the large lycopod *Bothrodendron* of the same region and the wide-leaved *Pseudo-bornia* of Iceland. All of these plants are leaf-bearing and are related in their general characteristics to the ferns, the horse-tails, the lycopods, *i.e.*, to the vascular Cryptogams.

But this ceases to be true with respect to the extremely archaic plants found in the Lower Devonian. An immense gap separates these from the former. Here we open our book of Paleobotany at a special chapter devoted to a new class of vascular plants, called the Psilophytales, a name recently invented to classify the most ancient terrestrial plants thus far discovered.

Previous to the year 1913, only the single genus *Psilophyton* was known to belong to the flora of the Lower Devonian age. This genus had been discovered by the English geologist, Dawson, in certain fossil specimens which were too poor in their contents to create a general conviction of the correctness of his view. Later discoveries, to be sure, made near Lake Röragen, on the line between Sweden and Norway, enabled Dr. Holle to affirm the existence of spiny, cylindrical stems, having neither leaves nor roots, but provided at times with terminal sporanges and corresponding closely enough to the *Psilophyton princeps*,

*Translated for the *Scientific American Monthly* from *La Nature* (Paris) for Jan. 1, 1921.

as the prototype species, described by Dawson, is called.

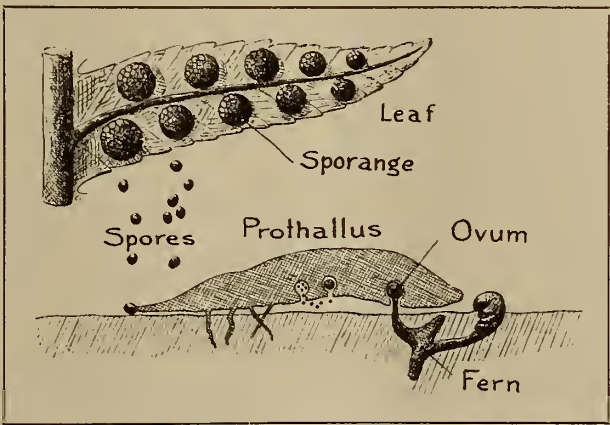
DISCOVERIES OF FOSSIL PLANTS IN 1913

A memorable date in Paleobotany is the year 1913, for in that year a discovery was made of a bed of fossil plants in the Lower Devonian (the epoch of the Old Red Granite) contained in a bed of turf from 2 to 3 meters in thickness, near the village of Rhynie in Aberdeen County in Scotland. Four silicified vascular plants capable of being studied under the microscope in the most minute detail have been obtained from this now celebrated deposit. These plants have been made the subject of an extensive study by Kidston and Lang (Transactions of the Royal Society of Edinburgh, Vols. XLI and XLII).

All four belong to the group of the Psilophytales, but differ so greatly from each other and from *Psilophyton* as to be classified in 3 genera, which have been called *Hornea*, *Rhynia* (containing 2 species), and *Asteroxylon*. The first two have both leaves and roots. The latter has no roots and but rudimentary leaves.

I. *Hornea.*—This is a sort of rhizome. It possesses rhizoids upon its lower surface, and from these there rise several bifurcated stems about 2 mm. in diameter; these stems are traversed throughout their entire length by a central cylinder surrounded by woody fiber. The central cylinder exhibits the same dichotomic ramifications as the stem which encloses it. At the end of the branches and forming simple differentiations of the latter are sporanges which are apparently indehiscent. The spores are tetrahedric in form.

II. *Rhynia.*—This plant, *Rhynia major*, is larger and better preserved than *Hornea*, but it has an equally simple structure. From the rhizome there arise several stout cylindrical stems, in which the microscope reveals a central cylinder having a bark and an epidermis provided with stomata. The latter and the vascular tissue furnish a proof that this plant was aerial in habit. The branches end in sporanges 12 mm. in length, having no columella or central axis and filled with tetrahedric spores.



THE ALTERNATION OF GENERATIONS IN A VASCULAR CRYPTOGAM

Rhynia Gwynne Vaughani, the second species of the genus, is smaller than *R. major*. Moreover its stems spring from toward the base of a sort of peduncular buds, *i.e.*, stem-buds, of superficial origin (possibly from the epidermis), and serve the purpose of vegetative multiplication, like the organs of the same kind found in some of the higher plants.

III. *Asteroxylon.*—Its base is formed by a rhizome branched in the same manner as that of the Stigmaria (the rhizomes of the *Lepidodendrons* and the *Sigillaria* of the Carboniferous Era), but naturally much smaller, since all of the plants of the Lower Devonian, including *Asteroxylon* were low-growing plants. In *A. Mackier* the stems were only 1 cm. in diameter. As in *Hornea* and *Rhynia* they were branched in successive forks, sustained by libero-ligneous bundles and ending in sporanges. It is necessary to dwell a bit upon these peculiarities in the anatomy of the plants.

In the case of a thin slice cut from the silicified stem of an *Asteroxylon*, just beneath one of its bifurcations, the central cylinder shows wood starred like that of certain lycopods. On the outside we see the sections of several leaves and the bundles which run to them.

The epidermis is pierced by stomata, which serve for the passage of the gases respired and for the assimilation of chlorophyll. In a longitudinal section it can be seen that the vessels are not scalariform, differing thus from those of the vascular Cryptogams. Finally, the microscope reveals the existence in the cortical cells of the stems and rhizomes of mycorhizes or filaments of symbiotic fungi, just as we now find them in the roots of forest trees of today.

The sporanges of *Asteroxylon* are comparatively small and are pear-shaped in form. Their dehiscense appears to have been terminal, whereas the sporanges of *Hornea* and *Rhynia* were indehiscent. From several points of view therefore *Asteroxylon* was more highly organized than the other two fossil genera of the *Rhynia* lignites.

A comparison of the foregoing plants with the *Psilophyton* of Dawson shows that there existed in Europe during the Lower Devonian epoch a remarkably homogeneous flora, composed of rootless land plants. They are archaic in nature, not only because of the lack of roots, but also because of the location and the structure of their sporanges.

The modern plants which most closely resemble the Psilophytals of the Devonian are the two genera *Psilotum* and *Tmesipteris*. The most common of the former, *P. triquetrum*, grows in the warm and humid portions of the tropics. It is a small plant which has no roots. Its rhizome is covered with rhizoids, and abundantly supplied with mycorhizes, whose office it is to assist the nourishment of the plant, which would otherwise suffer because of its very small leaves. The latter, indeed, are merely rudimentary, or rather they are reduced to the axillary bracts of which the sporanges consist. The whole, bracts and sporanges, send up from the surface a large number of tigellae or radicals borne by the rhizome; these are profusely branched in dichotomy.

Tmesipteris is represented by a single species (*T. tannensis*) found in Australia and New Zealand. It usually grows on the trunks of tree-ferns. Its form recalls that of a *Psilotum*, except that the rhizomes are more elongated and the leaves less rudimentary.

Holloway has shown that the embryo of *Tmesipteris* lacks roots from the very beginning of its formation. This indicates apparently that the absence of roots is primitive and not the result of a secondary reduction.

Before attacking the difficult problem of their alternation of generations it is advisable to sum up all the characters common to the *Psilophyta*, both of modern growth and of fossil origin. The six genera forming the group of the Psilophytal plants are as follows: *Psilophyton*, *Hornea*, *Rhynia*, and *Asteroxylon* in the Lower Devonian, together with *Psilotum* and *Tmesipteris* of our own day. All of these plants are vascular and do not bear flowers or seeds. But they are distinguished from the true vascular Cryptogams (which include ferns, lycopods, and horse-tails) by the lack of roots. This negative character causes them to resemble the mosses. But in their external aspect and some details of their anatomy (the wood starred in cross section) they approximate the lycopods.

In these plants therefore we possess *mixed or synthetic* types, which lessen the distance long thought to exist between the mosses and the vascular Cryptogams.

"It may be," says Professor Bower of the University of Glasgow, "that these two great phylums of terrestrial plants have diverged from a common stock. But this stock must have been closer to the plants of the Lower Devonian than to any other known plant."

We have spoken of the stems and leaves of the Psilophytals. But do these terms really fit the case? Do they represent organs really homologous to the true stems and leaves of the higher plants?

This question has been debated by learned botanists. Bower is of the opinion that the leaves of ferns, for example, which bear sporanges, have their origin in the enlargement and flattening of the stems of the Psilophytals. The sporanges, which are at first terminal, in the less highly organized ferns (*Osmunda*, *Ophioglossum*), just as they are in the Psilophytal group, come to occupy a central position on the lower surface of the leaves in the higher types of ferns; this, of course, is a mere change of position which is of secondary importance. But if the stems of the Psilophytals correspond to the leaves of the vascular Cryptogams and Phanerogams then what value should be attributed to the leaves of a *Rhynia* or a *Tmesipteris?* And what value again to the stem of a fern? Bower has suggested that the stems and leaves of the higher plants underwent a simultaneous differentiation, starting with the stems of the Psilophytals, and that the leaves of the latter are foliary excrescences without any homologue in other plants. However this may be, the important thing to remember is that the terrestrial plants of the Lower Devonian were remarkably simple in structure, having neither roots nor true leaves—somewhat resembling a green thallus.

Everyone knows that a fern—and the same thing is true of all the vascular Cryptogams—reproduces itself by means of the spores which are formed in the sporanges and fall from these, when ripe, to the ground. Let us follow the development of one of these spores (figure). It swells and expands and gradually produces partitions until finally a prothallus is formed, but this prothallus is by no means a new fern plant, since it has neither leaf, stem, nor root. In spite of this lack it lives upon the ground, obtaining nutriment from rhizoids, from chlorophyll and from microscopic fungi.

This prothallus is termed the *first generation*, and this generation even possesses the property of sex, since it is capable of forming ovules. From these ovules there spring a *second generation*, namely, the adult fern which is without sex, but produces *spores*.

But these ovules develop in the interior of the prothallus so that the ultimate plant is nourished by the prothallus during its youth, not becoming free from the first generation until later.

Now let us suppose that a fern does not become detached from its prothallus, but continues to obtain nutriment from the latter, while the roots, becoming useless, because the rhizoids of the prothallus take their place, cease to appear. In such a case the combined prothallus and leaf-bearing plant would form a nondescript rootless organism. But it is just such an organism which the *Hornea*, *Rhynia*, and the *Asteroxylon* of the Devonian most resemble. That part of the *Hornea*, indeed, which we have termed the rhizome has all the appearance of a prothallus persisting at the base of leaf-bearing stems.

The prothallus of the *Psilotum* and of the *Tmesipteris* was discovered in 1914, shortly before the outbreak of the Great War. The careful descriptions which have been made of it reveal that it was composed of colorless membranes living in symbiosis together with mycorhizes upon decomposing vegetable matter. This lowly form of life is amazingly similar to the prothallus of the lycopods.

INDUSTRIAL PRODUCTS FROM FISH AND MARINE ANIMALS

We have read many times that it is possible to make a very good leather from fish skins, but there are other products of commercial importance which are derived from fish and other sea animals.

The most important of these are the oils that are obtained from these animals and which have many important industrial uses. These oils are mainly codfish oil, whale oil, herring oil, menhaden oil and spermaceti. The last named product is really not an oil in the strict sense of the word, but a liquid wax. It does not contain glycerine and is constituted of fatty acids combined with the higher alcohols instead of the usual glycerine.

Fish oils are found on the market in various grades. The grade of the oil is determined by the method used in its production, by the nature of the raw material from which it is made and by the process of refination. A good example of how the grade of the oil determines its usefulness is found in codfish oil or cod-liver oil, as it is generally called. The best quality of the oil is used in medicine, while the lower grades are used in the manufacture of leather.

The extraction of the oil from the liver of the fish and from the fish itself at one and the same time is a technical detail of the greatest importance. To obtain the best quality of cod-liver oil, the fresh, clean livers are heated in caldrons which are provided with steam jackets. The oil exudes from the liver and floats on the surface of the mixture. From injured, diseased or putrid livers an oil of industrial use only may be obtained. In this case it is unnecessary to take as much care in the extraction process as in making the medical oil. During the last few years many extraction plants have been installed on the fishing vessels themselves, which has tended to reduce the chance of putrefaction of the raw livers. On the other hand there are processes where the livers and the flesh of the fish are extracted separately.

An oil is made from a mixture of all sorts of livers, good and bad, which is employed for various industrial purposes. It is used particularly in the manufacture of chamois leather. In the tanning of such leather, this oil is caused to penetrate into the sheepskin by suitable means and the skins are tanned due to the oxidation of the oil. The excess oil is recovered by pressing it out of the tanned chamois or by washing the latter with hot water. This expressed oil is known as degras and is very much sought for by leather makers and curriers. The demand for this product is so great that certain plants manufacture the product allowing the cod-liver oil to oxidize in the presence of sheep-skin waste. The oxidized oil is drawn off and new oil is added to the tanks in which the process takes place, the same sheepskin waste serving for repeated oxidations.

The deodorization of fish oils is an important process and there are many ways of accomplishing this. Without a doubt the best method is to hydrogenate the oil, that is to treat it with hydrogen gas. However, when this is done, the oil is hardened at the same time and a solid or semi-solid fat is obtained according to the degree of the hydrogenation. By the use of this method it is possible to obtain a fine white fat from an oil with very pronounced color to start with.

There are other methods of deodorization, but these are not as effective by any means. Fullers' earth may be used, and more recently pine wood sawdust has been reputed to give good results. Whale oil and other fish oils are used to considerable extent in the manufacture of soluble or sulphonated oils. Spermaceti oil is used for lighting purposes.

The composition of a great many fish oils has been determined by a Japanese chemist, who found that they all contain a very large proportion of unsaponifiable matter. This is due to their high content of a new hydrocarbon, called spinacene. This fact makes the oils entirely unsuited for soap making. It may be possible to convert these oils into fatty matters which can then be used in the manufacture of soap, in the same way that the Germans converted unsaponifiable mineral hydrocarbons into fatty acids and even into the neutral fats themselves.

Another product that has been made from fish is fertilizer and cattle food. The same product may be used for the two purposes with but a slight variation in the process of manufacture. In the case of the fertilizer the oily content of the meal is of no value to the farmer and in fact he prefers that it be absent. So, when the fish meal is intended for fertilizer use, the oils contained therein are removed with solvents. On the other hand, when it is to be used for cattle food, the oils are of considerable advantage and consequently are left in.

The Art of Writing and Its Early History

The Evidence of Ideography in Our Written Language Throughout the Ages

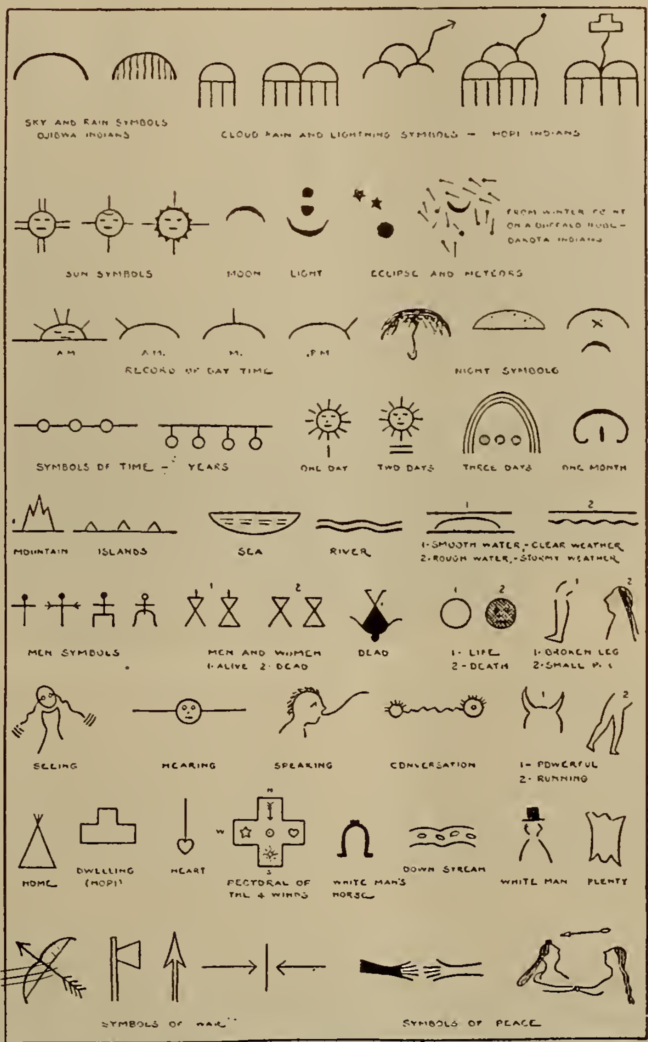
By Albert A. Hopkins

Fellow American Geographical Society

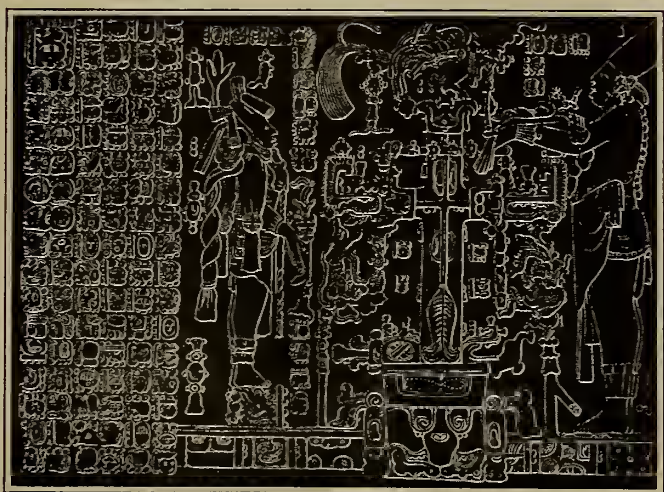
EVERYONE who reads a printed page in any modern language must have wondered at some time or other how writing as a permanent record of his own thoughts ever came to be used and also used as the representations or symbols of spoken words. Our processes of thought in the ever-widening environment of these busy modern days have become so automatic that we are prone to lose sight of the historical evidences of the long constructive past written large over the pages of our voluminous present. There is a whole volume of human history back of every one of the twenty-six alphabetic characters with which we write our thoughts and it was with this idea in view that Mr. William A. Mason has recently written an excellent book entitled "A History of the Art of Writing" which has just been published by The Macmillan Co. The bibliography of works on the art of writing is a long one, and occupies seven pages of Mr. Mason's work and could be extended to even far greater lengths by patient study. The two books which loom up from the sea of material are the book mentioned and Dr. Henry Smith Williams' monumental work entitled "Manuscripts, Inscriptions and Muniments," which was issued a few years ago in elephant folio form and which has recently been published at Cambridge, England, with a curtailed number of plates. It is to Dr. Smith's courtesy that we owe nine of the interesting illustrations which accompany this article.

The record unfolds to us the life history of these characters which have been designed, shaped and molded by many successive artists toiling under palm and pine; each are in turn modifying, altering and simplifying them, using them for the day and generation of his own race to pass them on as a priceless inheritance to other nations. If we examine the pages of a printed book in a European or Asiatic language (Chinese or its derived scripts being omitted) we will discover that the intended thought of the writer is conveyed to the mind of the reader by means of printed characters of abstract form which represent spoken words and which "spell out" the words phonetically, syllable for syllable, as they are pronounced. This basic principle holds true even though the English language may shake the fabric somewhat. The printed words that we read which are made up of the present, purely arbitrary characters which we know as alphabetic signs, convey to the mind through these abstract symbols word-pictures comparable to the primitive ideographic-idea pictures, which were the ancient precursors and prototypes of these symbols. These printed or written words of the classical parchments, the mediæval manuscripts and the modern books, it must be remembered, stand for the phonetic names of the intended things, representing them to the mind. By long association, however, these word-symbols, despite their apparently arbitrary character, call up to the mind of the reader the corporate things themselves; not only their names, but their forms, qualities, or attributes that the thousands of words in the language have come to represent. They are all idea-pictures as well as sound-pictures. In fact, they were idea-pictures first, ages before primitive culture of advancing man arrived at the conception of using these pictures as signs to represent phonetic sounds.

It is the purpose of Mr. Mason's book to prove by incontestible evidence that practically all systems of writing can be traced back through successive stages of development to a primitive age, long

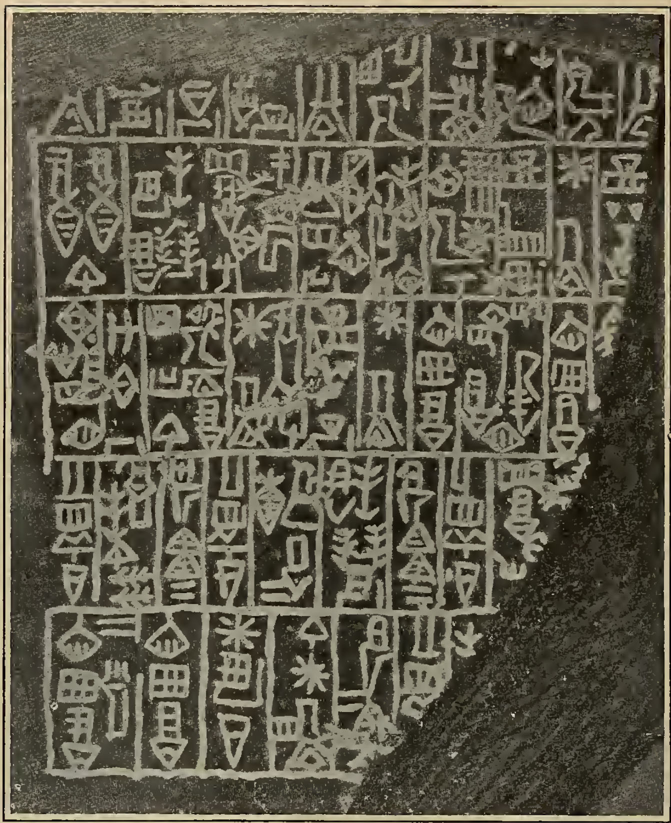


GRAPHIC SYMBOLS SELECTED FROM PICTOGRAPHIC RECORDS OF AMERICAN INDIANS (AFTER MASON)



MAYA HIEROGLYPHS, PROBABLY EARLIER THAN 1500 A. D. (AFTER WILLIAMS)

anterior to the invention of letters, when all records were merely the pictures of the things or ideas expressed. We have only to look about us in the world to discover that we have had quite up to the present generation, in the records of the aborigines of our own land, in the writing of the Chinese and of other nations, the contemporaneous use by different peoples the world over, of almost every phase of this world-wide and age-long evolution of the wonderful art of writing. For national development in the matter of writing has been most unequal. Some nations for one cause or another — racial backwardness, isolation, servitude or other unhappy causes contributing to it—never to this day have evolved any system of written record; while other nations, some even contiguous through all the centuries to these laggards in civilization, invented and practised the art of writing and enjoyed its beneficent results many millenniums ago. The African tribes, as is well known, though in contact with Egyptian civilization and its high culture over three thousand years before Christ, have failed up to the present day to develop any indigenous system of writing; while the history of Babylonian writing runs back to the fifth pre-Christian millennium. It is probable that the Homeric epics were chanted from memory during the early years of the second millennium before Christ, ere contact with the Phœnicians conferred upon the Greeks the art of perpetuating their heroics in visible, graphic form. The Romans, just before the birth of Christ, finding the Gothic barbarians of northern and western Europe illiterate and possessed of no other means of record than tallies of knotted cord and notched wood, taught them to write with the Roman letters. And the descendants of these same Europeans in the 16th and 17th centuries, coming in contact with the aborigines of this Western Continent, discovered them like children studying the primer of writing and drawing the pictures of the things and ideas that they desired to remember or to impart to others.

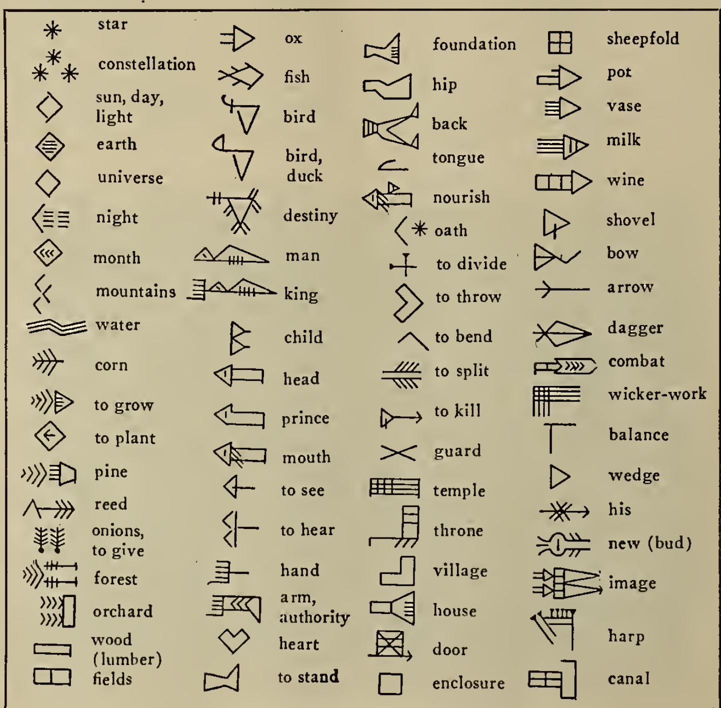


OLD BABYLONIAN WRITING (AFTER WILLIAMS), ON BLACK BASALT FROM ABOUT 4500 B. C. ANTEDATING THE CUNEIFORM, NO GENERAL AGREEMENT HAS BEEN REACHED AS TO THE TRANSLATION

It doubtless will be a still greater surprise to the reader to be told that there are yet retained in our language not a few of the primitive pictures that antedate writing, altered and modified, to be sure, through ages of use, during which interval they have become greatly simplified and conventionalized. All written languages contain these silent witnesses of their pictorial origin, existing like the persistence of ancestral traits in individual tribes; or to be nearer our point, like the roots of their spoken words converging different dialects back to a common linguistic parent.

The reader will notice in the pages of the book we are considering besides the alphabetic characters which we hope to be able to show later on probably are the corrupted forms of primitive pictures, other characters used as the representation of words that are not phonetic at all, but at a casual glance seem as arbitrary as the letters themselves, the component parts of printed words. They are in reality conventionalized pictures, in many cases retaining an indubitable resemblance to the things which they represent.

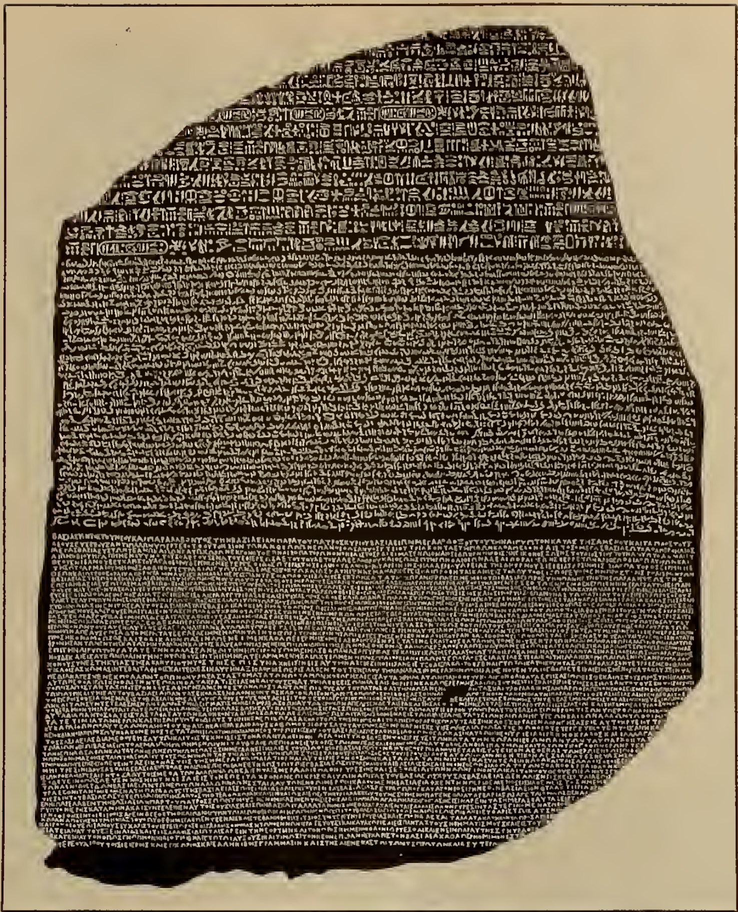
It will require no special appeal to the reader's imagination to foreshadow to him that this story of the evolution of writing deals with one of the most momentous agencies in the intellectual advancement of man. No other influences that man ever exerted has reacted so powerfully upon the development of his mental and spiritual nature as the invention of writing. Without the art of writing man would still be a savage as benighted as the unlettered heathen who still inhabit Darkest Africa. Without writing to conserve current ideas and ideals and transmit them to posterity, all advance in intellectual attainments, all uplift in spiritual thought that was not transmitted through the uncertain and errant instrumentality of memory would be lost. The acquisition of the art of writing above everything else distinguishes the civilized nations from the barbaric tribes; and whenever paleographic evidences are first met with in the life-history of any nation, we may confidently assert that the people practicing the art of writing, however crude the signs employed, were well advanced in the scale of civilization. It is this fact that makes any inquiry into the origin of writing a peculiarly interesting study, and the person who approaches the subject sympathetically will be amply rewarded, for he will see at every stage the noble strug-



BABYLONIAN IDEOGRAPHIC SYMBOLS (AFTER MASON)

gle, pathetic at times, of man's emergence from his primitive barbarism and awakening to a conscious sense of his obligations to others, and of his ultimate high destiny.

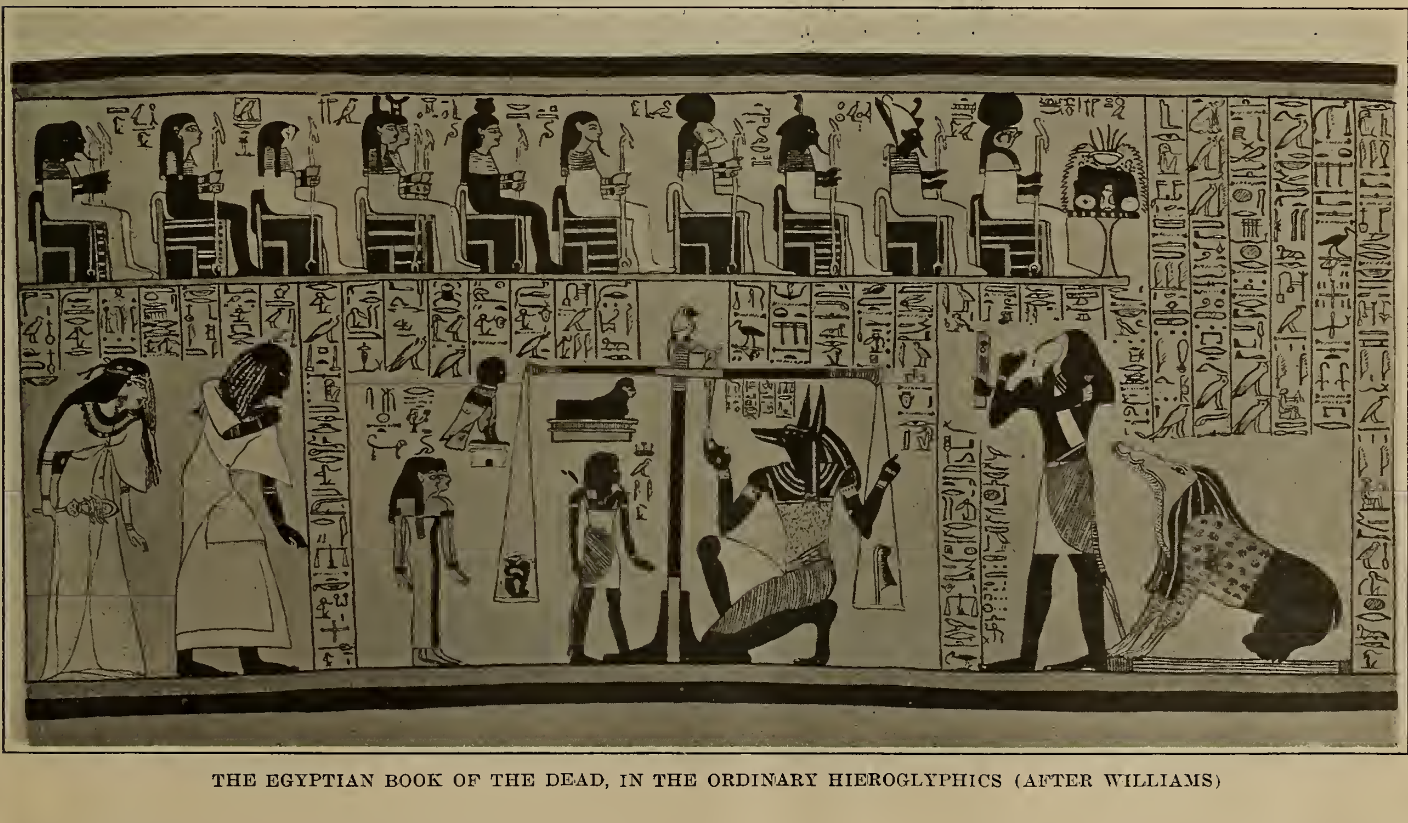
Mr. Mason's second chapter deals with primitive picture writing and gives as evidence interesting examples of rude pictures carved on bone by prehistoric artists, the rock paintings of the bushmen, such methods of computation as the clog almanacs, etc. The picture writing of the North American Indians comes in for an entire chapter in which the author shows that at the time of the European settlement of this country that the natives already had a system of picture-writing, wide-spread in its use but of limited comprehensibility even among the members of the same tribe or family. No tribe had advanced further toward true writing than the most elementary stage, that of pictography—drawing the picture of the thing intended, to recall it to the mind of the reader. The Dakotas and the Ojibwa Indians were about entering upon the second stage, that of ideographic writing when the intrusion of European culture interrupted the natural development of their native graphic system. We give an illustration from Mr. Mason's book showing the graphic symbols selected from the pictographic records of the North American Indians.



THE TRILINGUAL INSCRIPTION OF THE ROSETTA STONE IN THE BRITISH MUSEUM

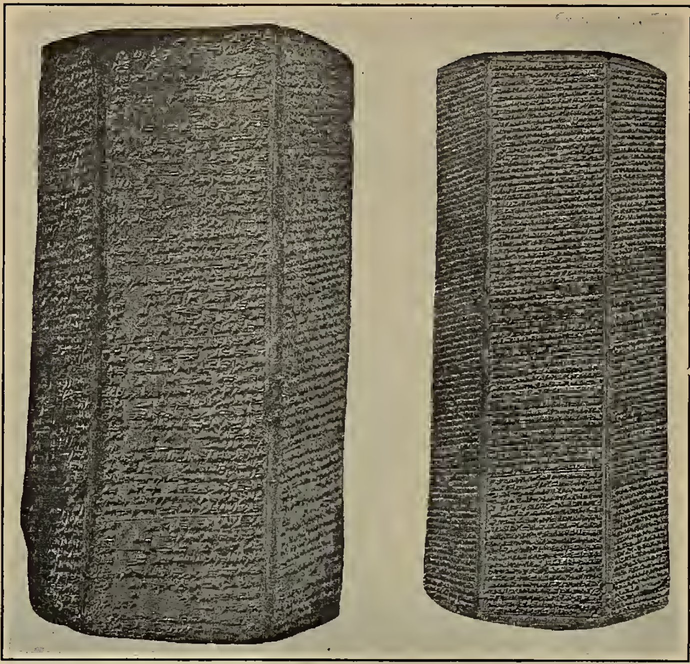
The fourth chapter is devoted to the picture writing of the ancient Mexicans and Mr. Mason says: "At the time of the Spanish conquest in the 16th century there existed contemporaneously in Mexico two centers of civilization, the Maya in the peninsula of Yucatan and the Aztec in the broad table-land of central Mexico where the present City of Mexico stands. Judged by the very scant remains of the arts of architecture, sculpture and writing saved from the ruins of these two Indian nations, their civilization and culture were quite the same, though the Maya was somewhat farther advanced than the Aztec. But the conquest of the country was so complete and thoroughgoing that when these Europeans had finished with their preliminaries, there was hardly a vestige of native culture left for rehabilitation.

"Cortes had no regard for any form of religion that was not based on orthodox Christianity. He was a religious bigot, so common in that age. Witnessing, therefore, religious ceremonies cruel in themselves and repugnant to his inherited beliefs, he ordered the destruction of every record that might



THE EGYPTIAN BOOK OF THE DEAD, IN THE ORDINARY HIEROGLYPHICS (AFTER WILLIAMS)

perpetuate this native religion. Obeying his harsh orders to the letter, his equally ruthless and ignorant followers set out upon the systematic destruction of the thousands of books, manuscripts and documents which this really highly advanced civilization had accumulated up to that time. Zumarraga, first bishop of Mexico, burned the precious manuscripts by the 'mountain heap,' five cities alone yielding up 16,000 books to the relentless Spanish governor, who destroyed every leaf. In Yucatan a similar fate overwhelmed the Maya civilization. The Spanish priests destroyed all books and manuscripts wherever they were found. Diego de Landa, second bishop of Yucatan, wrote: 'We find great numbers of these books, but as they contain nothing that did not savor of superstition and of the devil, we burnt them all; at which the natives grieved most keenly and were greatly pained.' Out of the tens of thousands of these sacred ceremonial books used by the Maya priests in their temples, and possibly other forms of native literature of a secular character, only a paltry few fragments are known to have been saved from this heartless and bigoted destruction.



BAKED CLAY CYLINDERS OF THE ASSYRIAN CUNEIFORM
Left: The annals of Essarhaddon, 681-668 B. C. *Right*: Annals of Assurbanipal, 668-626 B. C.; both from British Museum

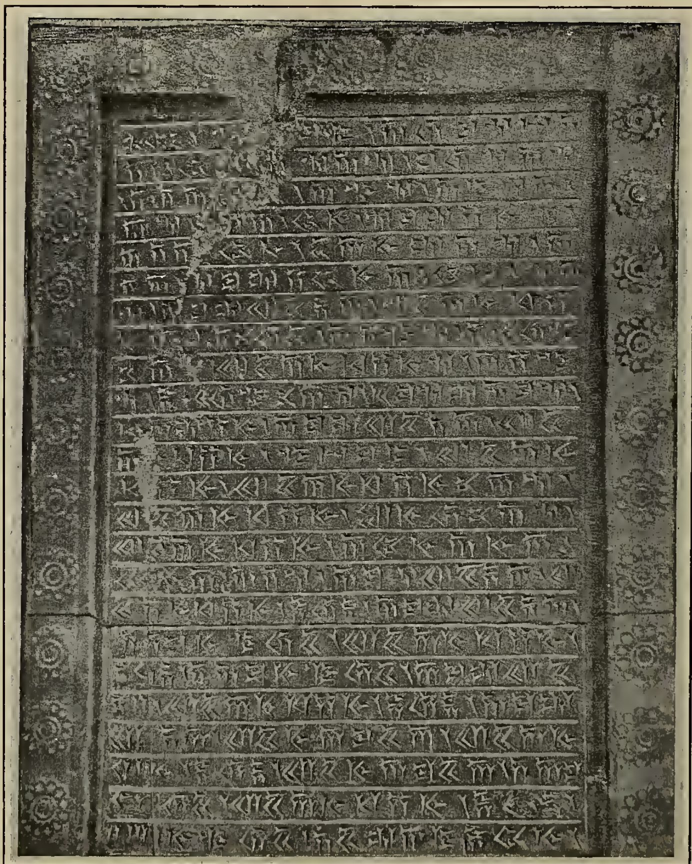
"But the Mexicans progressed a long step beyond the ideographic stage of writing. While they had not reached at the time of the conquest the point where each sound was indicated by a sign or a hieroglyph, they had arrived at a transition stage between the purely ideographic and the phonetic stage of writing. According to Dr. Daniel G. Brinton, the well-known Americanist: 'the native genius had not arrived at a complete analysis of the phonetic elements of language, but it was distinctly progressing in that direction.'

"In the Maya inscriptions, written or sculptured, it is evident that there were employed together with the ideographic pictures other elements, known as glyphs or calculi from their resemblance to pebbles, which symbolized syllabic sounds."

In the next chapter Mr. Mason discusses the hieroglyphic writing of the South Sea Islanders which is most interesting and then Chinese ideograph writing is taken up but space forbids to mention even more than the chapter heads, for we must pass to the hieroglyphic writing of the ancient Egyptians.

"Of all the systems of hieroglyphic writing that the people of any age have devised for recording or transmitting thought that of the ancient Egyptians stands preeminent, and looms in the popular imagination as the hieroglyphic system par excellence. It is the one that has given its own and the classic name to all such systems of writing. It maintains this unique position not alone on account of its historic and romantic associations, but for the artistic perfection, variety and clever ingenuity of its wonderfully fascinating symbols. Nothing in the way of writing ever has equaled the Egyptian hieroglyphic writing for its quaint picturesqueness, its extreme human interest, or for its beautifully decorative effect, whether sculptured on stone, painted on tombs or written on papyri. Entirely apart from their literary content, the arrangement of the hieroglyphic characters on the temple facades, friezes, columns, and over the broad wall spaces, added ornamental effectiveness to the architectural construction and enlivened its severe monumental dignity with their picturesqueness and variety of detail.

"In Rome there had stood since the time of the Cæsars as many as twelve Egyptian obelisks brought from Egypt by the early emperors to adorn the temples of the Eternal City. The import of their hieroglyphic inscriptions was not even guessed for over eighteen hundred years. It was not until Napoleon's spectacular invasion of Egypt offered the opportunity, that the decipherment of the Egyptian hieroglyphs was finally attempted and consummated. Every student is familiar with the story, now an historic romance, how Boussard, a young French artillery officer, discovered in the year 1799 near Rosetta, a few miles from Alexandria, the now famous Rosetta Stone, a slab of slate containing a tri-lingual inscription in hieroglyphic, demotic and Greek writing. The Greek inscription of course could be read; but the hieroglyphic, the sacred writing of the Egyptian monuments, and the demotic, the writing of the educated Egyptian people, were undecipherable, being in the unknown characters of an unknown tongue. The world long had awaited the genius of French initiative and scholarship to unlock the mysteries of Egyptian epigraphy and was immediately to be



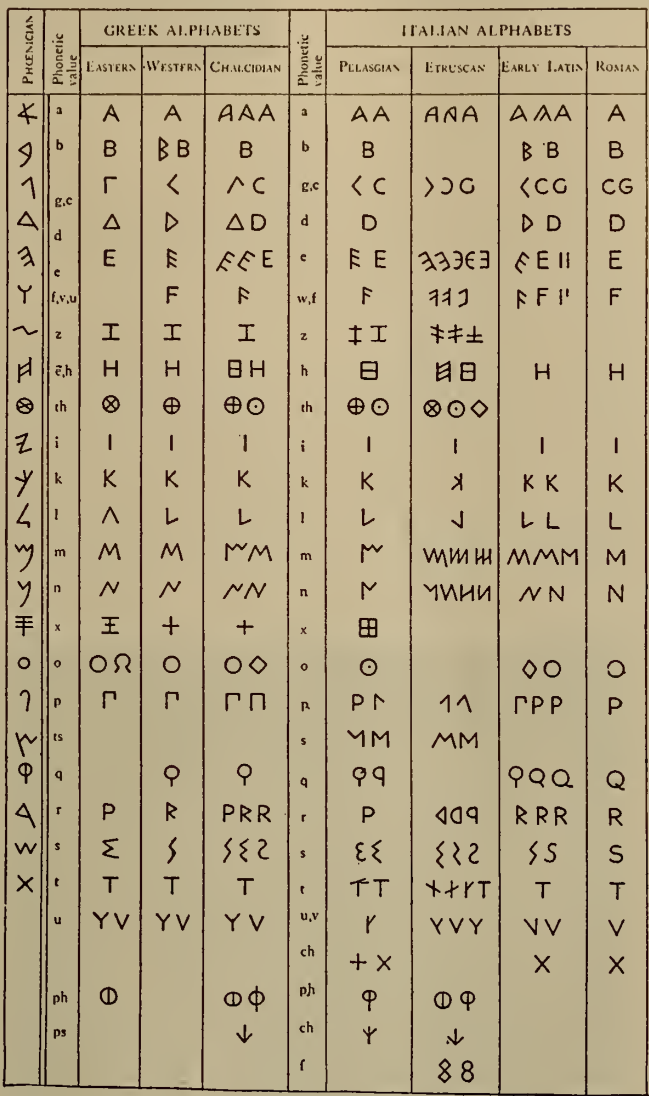
CUNEIFORM WRITING IN THE PERSIAN (ARTAXERXES III), RECORDING THE KING'S TITLES AND GENEALOGY AND THE COMPLETION OF HIS PALACE

enlightened. Jean François Champollion, a noted French scholar, turned his attention to the inscriptions and applied his scholarship to their translation with the most memorable success. He detected and rightly guessed that the name of Ptolemy, plainly read in the Greek inscription, was contained within the cartouches or ovals, several times repeated throughout the hieroglyphic inscription. It is now known that the royal names always were so written within these cartouches. Champollion previously had seen on the island of Philæ, before the Temple of Isis, an obelisk, since removed to Corfe Castle, England, with a single vertical line of hieroglyphics down the middle of each face consisting mainly of cartouches similar to those in the Rosetta inscription. Fortunately, at the base of this obelisk were two inscriptions in Greek, a petition to Ptolemy Euergetes II., consort of Queen Cleopatra, by the priests of the Temple of Isis, and the reply of the king.

"Little did these very clever priests of Isis dream that this stele, erected through such a transparent but successful palaver to the august Ptolemy, ultimately would become a potent factor in the decipherment of the hieroglyphs in which the inscription was written; far transcending in importance the trivial cause of its dedication and erection. Champollion in his investigations noted the similarity of the cartouches of Ptolemy in the Rosetta stone and on the obelisk of Philæ and subsequently identified the cartouches of Cleopatra in the latter inscription. By the help of common letters in the two names he was soon able to assign phonetic values to the twelve different hieroglyphic characters in these three cartouches."

The subject of cuneiform is very fascinating and Mr. Mason says:

"The full story of the origin of the cuneiform writing only lately has been fully demonstrated through the excavations conducted by the University of Pennsylvania at Nippur, by De Sarzec at Telloh, and other excavations in ancient Mesopotamia. In the higher strata of the débris of the ruined cities of Mesopotamia, containing the remains of the civilization of the middle and later kingdoms of Babylonia and Assyria, are found tablets containing inscriptions in the later cuneiform already referred to; but as lower and lower strata are reached, carrying us down to the remains of earlier cities, we find the characters gradually changing their forms from age to age, looking more like representations of actual things; until finally we come upon inscriptions in which the wedges have altogether disappeared, and each sign is drawn in lines—no longer writing as we know it, but veritable outline drawing. Thus may each puzzling cluster of wedges, which for a score of centuries served a great nation for the characters of its written language, a language exceptionally expressive and complete in its inflections, be traced back to its pictorial prototype. This early pictorial script, now known as the linear Babylonian, is distinctly representative, as we would naturally expect the archaic writing of a primitive people to be. In this respect it affords a confirmation of the theory of the almost universal pictorial origin of written speech. When all the missing links in the chain of development are supplied, it probably may appear that this early pictorial script was the parent from which have descended through the Hittite and Phœnician some of the letters of the Greco-Latin alphabet. It is yet too early to speak dogmatically in the matter, as so many transitional factors in the development are missing; but the weight of evidence seems to favor the far East as the source of some of our alphabetic characters."

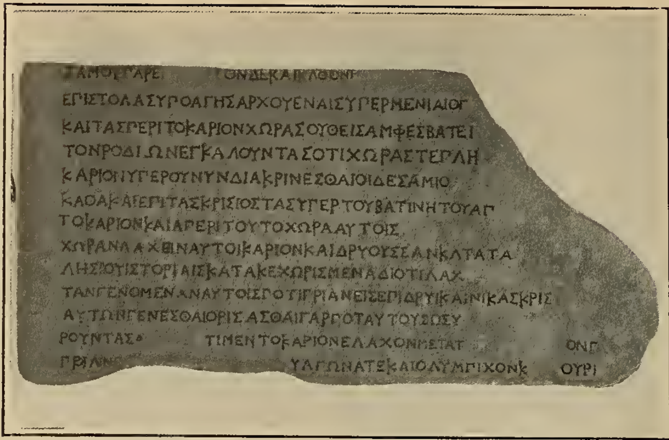


DEVELOPMENT OF THE ROMAN ALPHABET FROM THE PHOENICIAN AND GREEK (AFTER MASON)

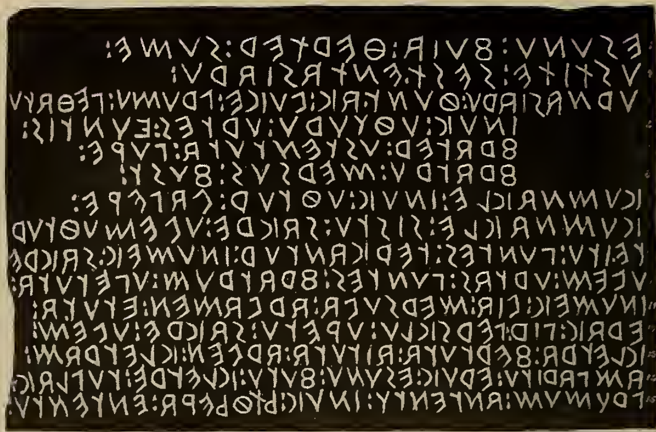
We derive much information from this book as showing the steps by which a written language has sprung from and developed out of primitive picture-writing as shown in one of our engravings. The hieroglyphic system of writing of the ancient Hittites claims a chapter, as does the alphabetic writing of the Phœnicians. We now come to the Greek alphabet and the subject is admirably handled by Mr. Mason in the limits of a single chapter after having worked up to this step by his evolution of the Phœnician alphabet as a probable source of the Greek alphabet. Mr. Mason says:

"No tradition seems ever more thoroughly substantiated, both by internal evidence and external fact, than that recorded by the Greek authors that the alphabet used in Hellas came from the Phœnicians. The classic authors differed in their opinions as to the origin of the Phœnician letters. Herodotus, the Greek, and Pliny, the Roman, believed that the Phœnicians invented the letters; while Brosius attributed them to the Babylonians and Tacitus to the Egyptians. But practically all the world now believes that it was the Phœnicians who introduced the letters into Greece proper."

We now come to Chapter XIII. which deals with the Roman alphabet. "The Roman alphabet, from which the capital letters of our English alphabet have descended with hardly the change of a single stroke for an interval of over 2000 years, was, according to the best historical evidence, developed from one of the early Greek alphabets, the Chalcidian, a variant of the Eubœan mode of writing. It was introduced into Italy at a very early date contemporaneous with the widespread Hellenic emigrations over the entire north Mediterranean shores, from the Aegean Islands to Spain, by Grecian colonists from Chalcis, who established themselves in Cumea, Sicily. It would appear that some time in the 10th century B.C., probably in the latter part and not so long after they had transmitted their precious alphabet to the inhabitants of



GREEK INSCRIPTION OF THE THIRD CENTURY B. C. (AFTER WILLIAMS). IT RELATES TO LAND OWNERSHIP



UMBRIAN BRONZE TABLET, PROBABLY EARLIER THAN 500 B. C. (AFTER WILLIAMS). IT REFERS TO THE SACRIFICE OF A SHEEP

Hellas, the Phœnicians retired from Greece and the Aegean. There then followed a rivalry for colonial supremacy among the Greeks. Miletus in Ionia contended with Chalcis in Eubœa, in Greece proper, for primacy in colonization. They eventually divided the territory of the Mediterranean between them, the Miletians being supreme in the east and through the Euxine, while the Chalcidians dominated Thrace and Italy. Thus it came about that the Western variant of the Greek alphabet was introduced into Italy," and after showing the evolution of the alphabet in a table which we reproduce, Mr. Mason goes on to say that:

"We now have reached in the classic days of the Roman civilization—a time about contemporaneous with the close of the Pagan period and the dawning of the Christian era—the complete development of the Roman alphabet. Its foundations were laid in the earliest Greek alphabets borrowed from the Phœnicians; its structure was framed by the Chalcidian, Pelasgian and Etruscan colonists in Italy; but the monumental perfection of these wonderful letters that the ages were so long preparing for us was the work of the Romans. The Roman letters in their extreme simplicity and remarkable mutual differentiation contain within themselves the elements of their popularity and widespread adoption. It is the most widely diffused alphabet in the world, being exclusively used in England, America, Australasia and South Africa, and is practically in use throughout Europe, except where the Gothic blackletter is employed in Germany and the Slavonic alphabet in Russia. It is also in official use in Egypt and India, and wherever the European nations except Germany, hold sway. The Arabic alphabet alone competes with it in universality, being used throughout Central Asia."

This does not terminate Mr. Mason's book for he deals (though briefly) with writing in the middle ages and the age of printing, but this occupies less than 100 pages. There is an excellent bibliography and the whole book bears the earmarks of the scholar who is enamored with his subject. It is a substantial contribution to serious literature.

ARCHAIC LATIN INSCRIPTION OF UNKNOWN DATE FROM THE ROMAN FORUM (AFTER WILLIAMS)

SELECTED BIBLIOGRAPHIES

Some time ago attention was called to a report of the committee of the American Chemical Society giving lists of books in various special fields of chemistry which were recommended for public libraries in particular. The American Ceramic Society's Committee on Coöperation now reports a selected bibliography of books in the English language dealing with ceramic chemistry and ceramic industries which is a supplement to the section on industrial inorganic chemistry in the chemical reading courses. The list is given in detail in the *Journal of Industrial and Engineering Chemistry* for May, 1921. The principal headings are chemistry and the ceramic industry, clay and clay products, glass and glass manufacture, vitreous enamel, refractories and cements, limes and plasters.

Although the ceramic industries are among the very oldest, comparatively little has been done as yet toward placing the industry upon a real scientific basis notwithstanding the advanced work done by several laboratories and many individuals connected with the production of clay products. Wider reading of the books listed ought to be, therefore, of great value. There is an increasing tendency toward research in clay and clay products and there might be mentioned the present cooperative research work involving the Bureau of Mines, Bureau of Standards, and the associations composed of the manufacturers of heavy clay products. Before long it is hoped that this work can be extended to include white ware and finer clay products, giving them a substantially complete list of titles for the entire ceramic field.

The Chemistry of Human Activity

Interpretation of the Transformation of Energy That Accompanies Muscular Work

By R. Vladesco

THE principle of the conservation of energy established by R. Meyer can be verified in all the physical phenomena thus far known to us. The remarkable fact observed in the study of the radiactive bodies offers no contradiction to the principle of conservation, if we look upon matter as being merely condensed energy. Without this hypothesis the two principles upon which all the physical sciences are based, *i.e.*, the conservation of energy and the conservation of matter, would lose their value.

As for the vital phenomena it is possible to affirm from the knowledge thus far acquired that the principle of the conservation of energy is as applicable to them as to physical phenomena. The vital phenomena consist of transformations of energy and the quantity of energy brought into action is always equivalent to the quantity eliminated. In both the animal and the vegetable kingdom we are familiar with the initial and the final forms of energy. In the vegetable kingdom the energy penetrates in the form of light and of heat and we find it fixed in great part, in the form of chemical energy. In the animal kingdom the initial form is chemical energy and the essential final forms are heat and mechanical labor.

In order to attain the final form the energy introduced is first transformed into other forms concerning which we have no precise data, just as we have no precise knowledge of the intermediate terms of the metabolism of metal. It is quite possible that these intermediate forms of energy are among those with which we are familiar in the physical world; but it is not impossible, on the other hand, that they may be of a different nature. These forms, from the moment they are derived from known forms until that when they are transformed into known forms, could not possibly occasion us more surprise than did the discovery of electric energy. It is in this light that we should regard the physiological labor introduced into the science of Bioenergetics by Chauveau and the intellectual energy which is considered by Ostwald as being derived from chemical energy during the transformation of the latter into heat.

So far as muscular activity is concerned an endeavor has been made to define the nature of the intermediate forms which occur between the initial chemical form contained in the food utilized by the muscle and the work performed by the latter.

Numerous researches made along this line, especially by Chauveau, have shown that the muscles utilize the energy contained in glucose and that the chemical energy of this substance is exactly equal to that liberated by the muscle in the form of heat and of mechanical labor. The production of work is always accompanied by the liberation of heat and under the best conditions of labor not more than one-fifth of the energy utilized is transformed into mechanical labor, the rest being liberated in the form of heat. Since the transformation of caloric energy into mechanical energy is among the first and the best known of the transformations which take place, it was natural to suppose that even in the case of muscular activity the chemical energy is first transformed into heat and that this heat is then transformed into mechanical labor. But such a transformation is impossible by reason of the fact that if we assume that it takes place, even under those conditions in which the animal machine may be supposed to act like an ideal thermic machine, we find between the extreme limits of temperature compatible with life a yield of work done which is perceptibly smaller than that which results from experiment. As a matter of fact upon replacing T_1 and T_2 in the formula which gives the value of the work done by a thermic machine, which acts according to the cycle of Carnot, by 273 + 45 (45° exaggerated) and by 273 + 37 we obtain the value $\frac{T_1 - T_2}{T_1} = \frac{318 - 310}{318} = \frac{1}{40}$; a fact that is as yet comparatively little known. We find in fact the following statement in a brochure by A. Stein: *Die Lehre von der Energie* (collection: *Aus Natur und Geisteswelt*):

"Every production of work by our body corresponds to an equivalent amount of heat liberated from the latter. Every work done of 427 m. kg. causes the disappearance in our body of 1 kilogram-calorie. If the expired carbon-dioxide be collected we can determine therefrom the amount of the carbon which had undergone combustion and also the relation between the amount of fuel and the mechanical labor performed just as we can in the case of a steam engine. Energy constantly flows into the body in the form of food and oxygen, from which it obtains a portion of the energy through the heat of combustion which it transforms into mechanical labor. Thus we see that our body and together with it the whole world of organisms comes under the law which governs energy."

In the *Traité de Physique* of Albert Turpain we find the same concept (Page 478): "When the animal moves or performs any labor a part of the heat produced by the chemical reaction is employed to perform this labor. Measurements have been made which show that the quantity of animal heat produced per gram of oxygen absorbed is less during movement than during repose (Hirn's experiments).

The difference represents the mechanical energy expended. These experiments confirm the common observation that the temperature of the body is increased by muscular labor such as running or violent exercise.

It has been observed, indeed, that during motion the activity of the respiration is increased. The amount of oxygen absorbed and measured is accordingly much increased and suffices to raise the temperature of the body, even though a part of the chemical energy is employed in the external labor.

Neither can the series of transformations assumed by D'Arsonval: Chemical energy → electric energy → mechanical energy, be accepted as correct, since serious flaws may be found in it. Chauveau assumes that chemical energy, liberated by the combustion of glucose, creates and maintains in the muscle an elastic force which may be expressed by this formula:

$$F = \left[p \pm \frac{m\,v}{\theta}\right]\left[1 + \frac{1}{2\,k}\right]$$

And that this elastic force is totally transformed into heat in the case of static work, and into heat and mechanical energy in the case of dynamic work. According to the results obtained by studying muscular elasticity this hypothesis would seem to be fully confirmed. But the question at once arises: By what mechanism is the chemical energy transformed into this new form of energy, elastic force?

The facts established by Chauveau concerning the physiology of muscle enable us to interpret the transformations of energy which occur therein in a manner which does not contradict the facts proved by experiment and which is in accord with what we know in regard to extra vital energy. Chauveau has proved that the muscle in a state of activity receives more glucose and more oxygen than when at rest and that it sets free a larger amount of CO_2. He believes that the chemical process which takes place in the muscle is an oxidation process:

$$C_6H_{12}O_6 + 6\,O_2 = 6\,CO_2 + 6\,H_2O$$

But this very process involves a liberation of work done; it is the work which corresponds to the decrease of concentration of the glucose in the medium in which it is dissolved. Better

*Translated for the *Scientific American Monthly* from the *Revue Generale de Science* (Paris) for June 15, 1920.

to understand this let us imagine a hollow cylinder with semi-permeable elastic walls, filled with a solution of glucose in which oxygen is also dissolved, and in which, thanks to the presence of an oxydose a part of the glucose is burned in accord with the above equation.

By means of this chemical transformation the molecular concentration of the liquid inside the cylinder is diminished, and the decrease is proportional to the quantity of glucose burned. The carbon dioxide set free exerts no influence at all upon this variation of concentration, since for every molecule of CO_2 liberated a molecule of oxygen is consumed.

If the cylinder is immersed in water or in a solution having a lesser molecular concentration than that of the liquid it contains the water will penetrate the interior of the cylinder and its form will be modified (because of its elastic walls) having a tendency to assume the form of the maximum volume, *i.e.*, the form of a sphere.

This theory agrees with the known facts observed in histology, concerning the active and the resting muscle. Apropos of this I will cite the lines which follow from MM. Athanasiu and Dragoiu:[1]

"The active elements of the striated contractile substance are dark disks. . . .

"During the contraction these disks decrease in height and increase in thickness; the rods which form a part of these disks have a tendency toward a spherical form.

"The sum total of all these elementary modifications of the dark disks is revealed by the entire shortening of the muscular fiber and its transverse swelling. But we have seen that the clear disks are also deformed during the contraction: they are stretched in the transverse direction, as indicated by the flattening of their elastic grains.

Are we not justified in assuming that these simultaneous changes in form indicate likewise a material exchange between these two kinds of disks? It seems to me that it is quite natural to suppose that it is at the expense of the water in the clear disks that the dark disks increase in volume, as a result of the osmotic pressure occasioned by the combustion of the glucose.

But it is now necessary to find out whether the work produced by this chemical process is able to compensate the value of any sort of labor and to endeavor at the same time to explain the rather extensive variability in the yield of the work done by the animal machine.

Pfeffer's researches have shown that non-electrolyte crystalloid bodies in solution behave precisely like gases—*i.e.*, the formula of perfect gases can be applied to them:

$$P V = R T$$

No matter how complicated be the chemical reaction which takes place in the organism the work performed by it can be calculated by means of the equation of Van t'Hoff. In practice, however, we find that blind application of this equation leads to absurd results, even to infinite yield of work under some circumstances. It is necessary to modify the procedure by superposing upon the equation the physical limitations of the problem, so that the yield of work will be limited by the total amount of energy present in the substances under consideration.

If the reaction took place in the organism as has been supposed, and if the ratio between the concentration at the beginning and the end of the reaction were in excess of a definitely determinable value, then the animal machine would be unique and would represent the most perfect attainable device for the transformation of one kind of energy into another. However, in reality, of the total amount of energy contained in the chemical sub-stratum placed at the disposal of the muscle, only a fraction whose magnitude depends upon various conditions is transformed into mechanical labor, while most of the rest is changed into heat.

[1] I. Athanasiu and I. Dragoiu: *Association of the Conjunctive Elastic and Contractile Elements in the Smooth and Distriated Muscles of Mammals.* (In French Ann. de Biol. 1911, Vol. 1, No. 2.)

We could then determine the ratio of the concentration of the glucose existing between the venous blood and the arterial blood in the case of a muscle whose yield is known and reciprocally we could calculate the yield provided we knew the ratio between the concentrations, it being supposed, of course, that the muscle consumed no part of its glycogen reserves. The work done by this chemical reaction would be compensated consequently within the limits of the known energy of the glucose, for any sort of muscular labor no matter what and the variability of the ratio of the concentration—before and after the reaction—would furnish an explanation of the variation in the yield.

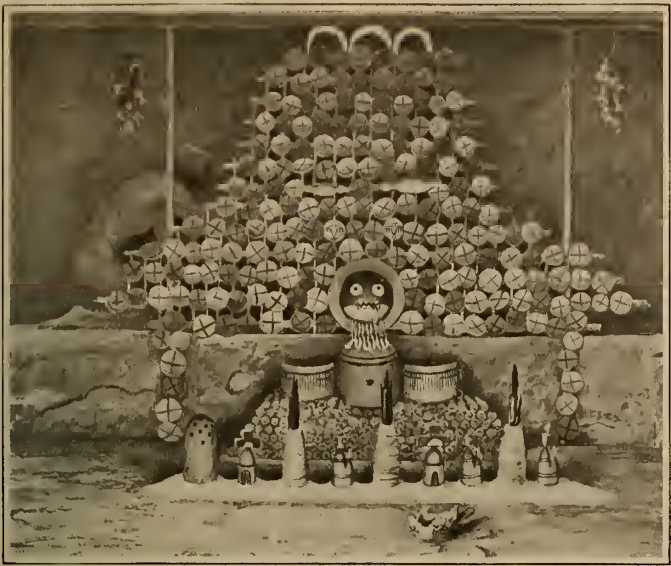
Thus of the total energy contained in the glucose, a portion, determined by the value of the ratio between the initial and the final concentration, is transformed into mechanical labor while the remainder is set free in the form of heat. These two portions vary in inverse ratio with respect to each other, but their sum total always remains equal to the total quantity of energy contained in the glucose consumed.

But it appears that this supposition contradicts what really occurs since experiment has demonstrated that the quantity of heat liberated augments with the work performed. But it is probable that the limits of variability are not sufficiently far apart to render evident this relation between the two portions of the energy.

Furthermore, we shall understand the purpose of the variability of the ratio between these two portions of the energy when we reflect upon the exceedingly great variability of the needs of the organism. In this manner the nervous system is capable of satisfying these widely varying needs of the organism. This variability is capable of explaining also the possibility of improvement in the animal machine as to the useful work done (the yield) by means of functional gymnastics. The non-consumed glucose becomes fixed in the muscle in the form of glycogen constituting here a store of chemical energy. This deposit is capable of satisfying the requirements both of muscular labor performed by the organism and providing for its calorific needs by means of the combustion of the glucose derived from the glycogen. In the case in which the glycogen undergoes direct combustion, *i.e.*, without being transformed into glucose the available chemical energy is transformed completely into heat because the action of the glycogen from the osmotic point of view has no effect. But when the chemical process becomes more intense, *i.e.*, when the quantity of glucose consumed is greater, the two portions of the energy available will increase at the same time.

Moreover, it seems that this view is confirmed by experiment since whenever there is an increase in the amount of work done the temperature also increases. If this is the true explanation of the matter the heat produced in the organism can no longer be considered a mere excretion which was later adapted to the purpose which it now fulfils. It must, on the contrary, have been designed from the very beginning to perform a definite function quite as important as the muscular function.

The term *excretum* as applied to heat would be justified solely in the case of the heat which inevitably results from all labor which is sterile from the mechanical point of view. Furthermore, this theory of heat as an excretion is not accepted by all physiologists. Professor Athanasiu of Bucharest holds that from the chemical energy contained in the glucose there issue originally all the forms of energy observed in the organism. He holds contrary to Chauveau's theory that heat also results from the same deposit of potential (chemical) energy without passing through the intermediate stage of physiological labor. According to this savant the supposed intermediate form of energy termed physiological labor is neither necessary nor logical, and as a consequence heat does not deserve in all cases to be designated as an *excretum*. It is this difference between the two views of the matter held by Chauveau and by Athanasiu which form the point of departure as the interpretation given above.



STRUGGLE OF SERPENTS AND MUDHEADS, ONE INCIDENT OF THE VERNAL EQUINOX OBSERVANCES

ALTAR ON WHICH THE WINTER SOLSTICE CEREMONY IS CARRIED OUT AT WALPI

Sun Worship Among the American Aborigines

The Ceremonies Attached to the Deification of the Orb of Day

By Webster P. True

THE passing centuries have drawn a veil over the life and customs of the American aborigines, and it is only as this veil is torn aside by the work of the archeologist that we begin to see the purpose and meaning of the fantastic ceremonies and religious rites of these earliest Americans in the misty dawn of history on this continent. And yet this very veil of mystery and uncertainty surrounding the past arouses the interest and stimulates the imagination, though no flight of imagination can exceed in weirdness certain of the ancient rites of the cliff dwellers of the southwestern United States, especially in the various forms of their worship of the sun. It is in large measure to Dr. J. Walter Fewkes, chief of the Bureau of American Ethnology of the Smithsonian Institution, that we owe our present knowledge of the prehistoric American cliff dwellers, and in the course of his thirty years of archeological research he has uncovered many ruins of these ancient communal cliff houses, and has brought to light a great amount of knowledge concerning the customs and religious practices of the Indians of the Southwest. It is especially with sun worship among the Hopi Indians that Dr. Fewkes is concerned in the last issued report of the Smithsonian Institution.

One method of arriving at the real meaning of the mysterious and involved ceremonial practices of the civilization which rose, flourished, and passed away among the cliffs and canyons of the Southwest long before the white man had penetrated thus far into the new continent, is by a close and scientific study of the surviving rites and religious beliefs of the present-day Indians, which, though modified somewhat through the centuries, still retain much of the early myths and rites. It is this method which Dr. Fewkes discusses in his most recent study of sun worship.

To begin with, it appears from a study of the ceremonies that the religion of the Hopi Indians is chiefly for the purpose of securing for themselves sufficient food and other blessings of this world. They worship the power that causes the rain to fall on the earth, for without rain the maize or Indian corn, their chief food resource, withers and dies, leaving them practically without food. Their observations of the sun early led them to know accurately by its position when the time was ripe for corn planting and when the rainy season, necessary for its growth, might be expected. Thus climatic conditions —rain, drought, cold, and warmth—were the foundation of their worship of the sun, and the supernatural power back of the earth and sky, respectively fertilizing the seed and enabling it to grow to maturity, was a magic force which must be worshipped, placated, and sometimes even compelled by magic to act favorably for the assurance of a food supply. Naturally there are many forms of this sun worship, but underlying all is the primitive realization that there is a power back of the sun which controls conditions of climate, and it is the various representations and symbols of this power which are exalted by the Hopi and other Indians, and to which are dedicated the complex of rites and ceremonies making up sun worship.

The representations are weird and often theatrical, as for example the elaborate rite of "calling back the sun," which occurs among the Hopi near the end of December. The Sun priests have for weeks been anxiously watching the sun go down over the horizon, receding daily farther and farther toward the south, until it seems to the watchful Indians that it must surely intend to withdraw permanently. At last, however, it reaches its furthest southern point and the announcement is made publicly that the sun has gone to his home in the west. Now must the great effort be made to bring the sun back to his people. The stage is set in one of the ceremonial rooms or kivas, occupied only by the sun clans and sun priests, mostly old men, and the principal rites are held here in secret. A screen is erected near one end of the room through the center of which is thrust the head of a serpent effigy, and in front of which are spread various symbolic materials, most prominent being a stack of ears of corn from which the future seed will come. In front of the screen stand masked men representing supernatural beings, and around the walls sit the chorus who during the ceremony sing weird songs and accompany them with rattles. When the priests have smoked the ceremonial pipe, events begin to happen. A step is heard on the roof of the kiva, and soon the Sky god announces his arrival by throwing a ball of sacred meal through the opening in the roof. Cries of an eagle produced by means of a bone

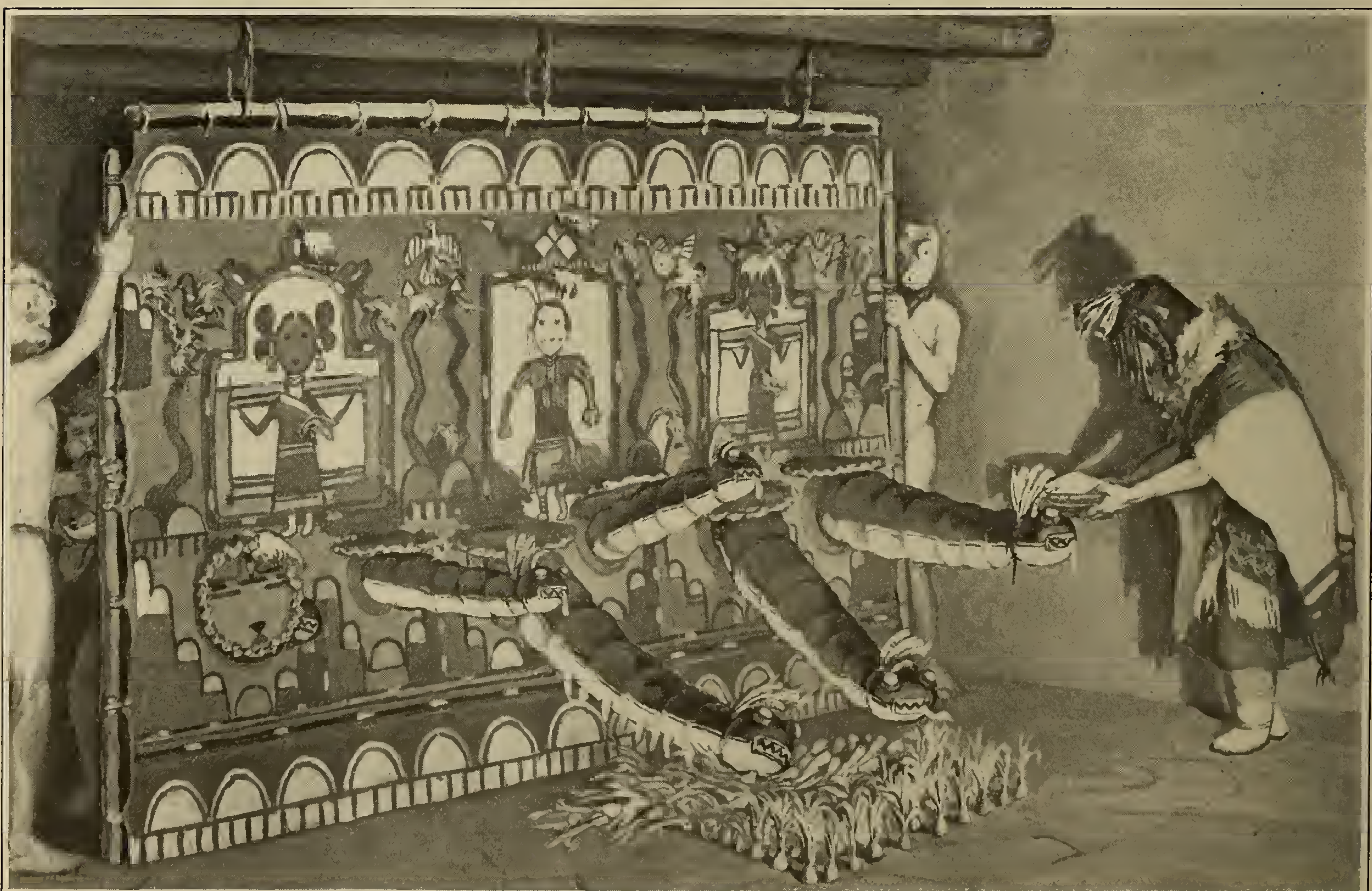
whistle are meant as an invitation for the god to enter, and soon he descends into the kiva. He is elaborately dressed to represent a bird, his head and body being covered largely with feathers, and more feathers are attached on a string across his shoulders to represent wings, which he flops up and down.

Having strutted around the room several times imitating a bird, he walks directly up to a maiden seated in one corner who represents the Earth maid. In front of her is a pile of sand in which are sticking several arrows. The Sky god, bending his body almost to the ground, grasps an arrow in each hand, straightens up with a loud cry, and quickly hurls them back into the sand. This is repeated several times, and the meaning, plain to see, is the call of man to the god to make fertile the earth, represented by the Earth maiden, by means of the lightening, symbolized by the arrows. During the numerous circuits of the room made by the Sky god in the course of this ceremony, he receives many prayers from the assembled priests, and the purpose of the imposing rite is not only to call back the sun, symbolized by the appearance of the Sky god, but also to urge the sky power to fructify the earth that the Indians may have abundant crops.

The horned or plumed serpent mentioned in the ceremony above is a personation of the Sky god and is worshipped in conjunction with the Sun god. This sacred serpent plays a prominent part in the series of weird dramatizations which take place among the Hopi at the time of the vernal equinox, and which are probably the most remarkable series of religious ceremonies ever witnessed among any tribe of the American aborigines. The performance takes the form of a series of acts, and the stage is prepared nearly as described above. The spectators are ranged about the walls of the sacred room, and the kiva chief is crouched over the ceremonial fire, feeding it from time to time with sticks of greasewood, and covering it with a blanket to produce darkness when it is necessary to change scenes. A tramping is heard on the roof of the kiva as before, and on being invited to enter, a number of men descend the ladder into the darkened room. They are busy with their paraphernalia for a short time, and when the fire is again allowed to light up the room, there is disclosed to the spectators a cloth screen containing many symbolic designs, the most conspicuous being six discs across the screen on which are painted symbolic pictures of the sun. The participants in the ceremony are a number of naked Indians called Mudheads on account of the strange masks they wear, which consist of a case over the head studded with knob-like projections over the eyes, mouth, and ears, giving them the appearance of some strange, uncouth animal.

At once, a chant is begun by these men, the six sun discs swing open, and from each opening comes out the black head of a serpent effigy manipulated by a man behind the screen; one, larger than the rest, called the "mother serpent." As the chant goes on, the serpents sway their heads and bodies fiercely from side to side, attempting to bite one another, while from back of the screen comes a roaring sound, the fancied cry of the horned serpent. The song rises louder and higher, and the serpents sway faster and attack each other more and more viciously. Suddenly at the height of the clamor, the "mother serpent" sways her body to the floor and attacks the imitation corn field consisting of little cones of clay with a corn plant in each. These are knocked down and scattered about the floor, and at once the serpents raise their heads, and a man dressed as the Earth woman offers them food in the form of sacred meal. The serpents are then drawn back through the screen, the kiva chief gathers up the scattered corn plants and passes them around to the spectators. This weird act undoubtedly represents dramatically the fertilization of the corn by the Sky god, personated by the horned serpent effigy. It is only one of six similar acts in this elaborate sun worship drama.

Thus in their ceremonial rites the Hopi dramatize various events connected with the sun in an effort to cause him to make fertile the earth and insure for them an abundant harvest. In certain other rites the struggle against hostile super-



THE SERPENT SCREEN AT WALPI

natural powers is represented, as for example those powers whose malign influences cause the growing season to be too wet or too dry for the best yield of corn. In one of these rites, the struggle is dramatized by actual conflict between men dressed to represent these supernatural beings, which take place secretly at night in the sacred kiva. One man representing the beneficent power of the sky and displaying on his shield the Hopi Germ god, stands alone before the altar, while his opponents, bearing shields with various other emblems, stand in two rows on each side of the room. As these men personating the hostile powers surge up against the supernatural being alone in the center, a chorus begins a low, weird chant which, as the contest waxes fiercer, increases in volume and tone until it becomes a wild war cry. Suddenly one of the hostile powers separates himself from the mass and engages in individual conflict with the Germ god shield bearer. These two combatants are locked in furious struggle for some time, until finally the attacker is overcome and falls to the ground exhausted, in which condition he is carried out. Another and another take up the attack amid great shouting and excitement, and each is overthrown in turn until the lone man stands victorious. Holding his shield high over his head and uttering a prayer symbolizing victory, he leaves the room as the excitement subsides.

On the morning after this victory over the hostile powers of the sky, there enters the pueblo a masked man dressed to represent the Sun god and wearing his symbols. He is accompanied by two men dressed as women, who carry trays containing ears of corn arranged in a circle, within which are symbols of sprouting plants. These three persons, representing the beneficent power of the sky, pass through the village, presenting to the head of each clan one of the sprouting plant symbols. Thus do the Hopi dramatize their effort to thwart the evil powers and encourage the Sun to fructify the earth and bless them with a rich corn crop.

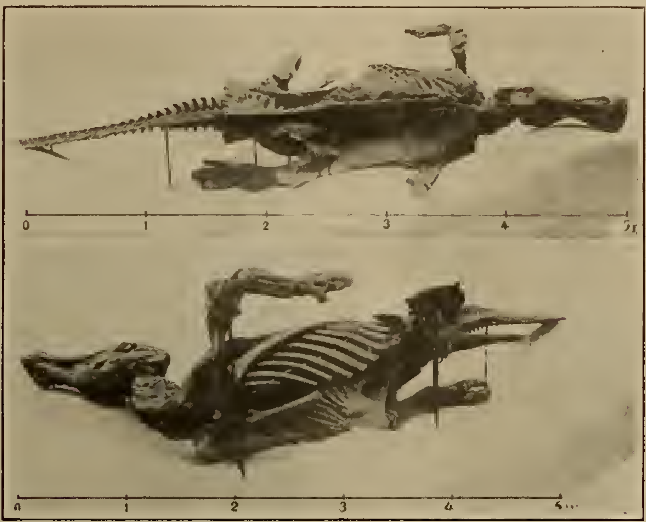
Many of the secular customs of this tribe illustrate their recognition of the power of the sun and its influence over their lives. When a babe is born among the Hopi, a scratch is made on the wall of the house by its mother for each day from the date of its birth until the twentieth day is reached. The time is then ripe for the impressive ceremony of consecrating the new life to the sun and giving it a name. The rites begin about four o'clock of the following morning, when the room is thoroughly cleaned and the baby carefully washed. Its face is then covered with sacred meal and an ear of corn is fastened on its breast. This corn represents symbolically the mother of the child, and it is carefully kept during its life. As the time for the sunrise draws near, the baby's father seats himself on the roof of his dwelling facing the east, and covers himself with a blanket, leaving only his face exposed. He gazes steadfastly toward the east, and as the first light from the rising sun appears, he gives a signal and a procession comes forth from the room with the mother in the lead, followed by the grandmother carrying the baby in its crude cradle. As the mother advances across the roof toward her husband, she leaves behind her a straight trail of sacred meal, and the grandmother following holds the child so that its head stays directly over this line. This act symbolizes the desire that the child's life may be morally straight, and may never deviate from the line drawn symbolically by its mother. The head of the slowly-moving procession reaches the father just as the sun himself appears over the horizon, when the grandmother holds the baby up and its mother repeats a prayer consecrating her baby to the sun, the "father of all life," and pronounces the name which she has selected for it. The procession then returns to the house where a feast has been arranged.

Various other rites connected with their reverence of the sun power are performed during the life of an individual, and even at death he is buried looking toward the rising sun, and is addressed as follows: "You have become a Katcina. Aid us in bringing the rain, and intercede with the gods to fertilize our farms."

"In individual rites from birth to death," says Dr. Fewkes, who has himself witnessed most of these weird ceremonies dedicated to the Sun, "the worship of the Sky god, in the form of the Sun god, is always present in the Hopi mind, as well as in their great dramatic ceremonies."

A MUMMIFIED DINOSAUR

The vast ice fields of Siberia have in many instances acted as a natural cold-storage plant for the preservation of the flesh of the mammoth, this prehistoric cousin of the elephant having been dug out of his chilly grave intact on numerour occasions. It has always been supposed, however, that this was the only instance in which anything more than the bare bones of the fauna of past geological epochs had come down to us. Doubtless the mammoth will continue to stand unique in this respect; but he is no longer unapproached. There has recently been put on exhibition in the Senikenberg Museum, Frankfort-am-Main, a dinosaur skeleton which carries with it a considerable portion of the skin of the animal, in mummified form. In particular the epidermis over the animal's back is present practically intact. The skeleton has been mounted in flying position, and makes altogether an impressive exhibit, as our illustrations with the meter-scale sufficiently suggest.



TOP AND SIDE VIEWS OF FRANKFORT'S MUMMIFIED DINOSAUR, WITH A SCALE IN METERS (APPROXIMATELY YARDS) INDICATING HIS SIZE

ELECTRONIC AMPLIFIER FOR LOW ANODE VOLTAGE

E. Ruchardt (*Jahrb. d. drahtl. Tele.*, Jan., 1920), describes experiments carried out at Würzberg University on a special type of thermionic valve characterized by its small dimensions and by the filament being placed *between* the two plate-electrodes corresponding to the normal grid and anode. The theoretical considerations of this form of valve are dealt with according to the methods of Barkhansen, and the usual grid-voltage anode-current curves are illustrated. These show that in its final form, better results than with a normal 90-volt amplifier are obtained by this valve with 13 or 20 volts anode current.

Various schematic representations for the use of this valve in two-valve amplifiers are illustrated and the amplification variation with frequencies from 400 to 1160 cycles are tabulated. The chief value of this valve, experiments on which were discontinued at the end of the war, is that it permits of a considerable reduction in anode voltage as compared with the normal valve.

The Ciphers of Porta and Vigenére

The Original Undecipherable Code, and How to Decipher It

By Otto Holstein

THE origin of Cryptography is lost in the mists of the past. The earliest use made of Ciphers, to our certain knowledge, was by the Spartans long before the Christian era. Its origin is probably contemporary with that of the art of writing itself since there was hardly a time when the need or desire for means of communicating intelligence secretly did not exist.

Ciphers were employed in the days of Cæsar and we have definite knowledge of the systems then in use. During the Renaissance cipher communications reached their most extensive use and most of the intrigues of those days were conducted by secret communications and many actual examples thereof are still extant and these have furnished material for the later day cryptographer to exercise his skill on.

Who has not read Poe's "Gold Bug" and who has not marveled at the almost supernatural acumen that appeared to operate in the solution of the secret communication that betrayed the hiding place of the treasure?

Until the 16th century ciphers were more or less simple in their construction and operation, although probably adequate for the purpose for which they were employed. In the year 1563, however, the Neapolitan physician Porta evolved and described the first cipher whose operation depended upon the use of a key-word, key-phrase or group of letters, agreed upon and changeable at the will of the correspondents. Twenty-three years later, in 1586, the French physicist Blaise de Vigenére brought out a system identical in results with that of Porta but somewhat more simple and more easy to operate.

The Cipher of Vigenére which is more commonly known as the "Alphabetic Square," the "Russian Square," the "Multiple-Alphabet Cipher," etc., takes the following form:

As the working of the system may best be explained by example, let us take for our key, say, the word CIPHER and, given the example: CIPHERS EMBRACE ALL MEANS WHEREBY WRITINGS MAY BE TRANSCRIBED IN OCCULT TERMS, the communication may be prepared for encipherment by being written out in the usual manner, the key-word being written above, letter over letter, thus:

C I P H E R C I P H E R C I P H E R C I P H E R C I P etc.
C I P H E R S E M B R A C E A L L M E A N S W H E R E

or, a better plan still, the key-word is written and below in columns—equal in number to the letters of the key-word—the text to be enciphered, leaving space under each line for the cipher letters as found, thus:

C I P H E R
C I P H E R

S E M B R A

C E A L L M

etc.

This latter system offers the advantage of permitting each column to be enciphered with the corresponding alphabet in turn—an advantage that will be better appreciated in practice.

The communication having been thus prepared, the Vigenére Table is referred to and the first letter of the key-word ("C" in our example) is found in the top horizontal line and the first letter of the communication (likewise "C" in this case) is found in the vertical column of capital letters at the extreme left of the table and the letter in the table at the intersection is taken as the cipher letter ("e" in the present instance). The reverse of this process, *i.e.*, locating the key-letter in the left hand vertical column and the plain-text letter in the top horizontal line will give identical results, as trial will prove. Proceeding in like manner "I," the second letter of the key, and "I," the second letter of the communication, give "q" as the cipher equivalent; the third letter of the key, "P" and the corresponding letter of the plain text, "P" give "e" as the third cipher letter and so on, the enciphered communication appearing as follows:

EQEOI IUMBI VREMP SPDGI CZAYG ZTICN TQIQR XUUPF FVVZP UWTTQ QLHZP WRJYC VBTYQ JXXXX.

The enciphered communication is invariably written in groups each of an equal number of letters which serve as a check to the receiver (when transmitted by telegraph, radio, telephone, visual signal or the like). The four final letters "X" being added to fill out the last group to the requisite number of letters. Likewise, in the light of what is to follow, it would obviously be playing into the hands of the decipherer if the original word grouping of the letters (EQEOIIU MBIVREM PSP DGICZ AYGZTIC, etc.) were preserved or if the communication were written in groups corresponding

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
B	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a
C	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b
D	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c
E	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d
F	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e
G	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f
H	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g
I	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h
J	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i
K	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j
L	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k
M	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l
N	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m
O	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n
P	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Q	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
R	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
S	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
T	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
U	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
V	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u
W	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
X	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Y	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x
Z	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y

THE VIGENÉRE TABLE

to the number of columns in which it was enciphered (in this case EQEOII UMBIVR EMPSPD, etc.) so the communication is broken up into arbitrary groups, each of a given number of letters, for the purpose of disguising the word forms as well as the number of letters in the key-word and to serve as an index to the receiver, as has been explained.

To decipher a communication, being in possession of the key, the key-letter is found in the top horizontal line of the table and the column at the top of which it is found is traced downward vertically until the corresponding letter of the enciphered text is located, then tracing along the horizontal line so located in the table to the extreme left, the letter appearing thereat will be the plain-text letter. In the case of our enciphered example, "C," the first letter of the key-word is found at the top of the third column, tracing down this column until the first letter of the enciphered communication "E" is located and following the horizontal line so located to the extreme left of the table the first plain-text letter "C" will be found.

To this point and no further extends the knowledge of the average person who knows something of ciphers but who has not made the subject one of deep study and analysis. The most remarkable views are held regarding the absolute security of this particular system! The champion of this and like systems at once points to the fact that in ciphers of the simple substitution type (Poe's "Gold Bug" cipher belongs to this class) where a letter of the plain-text is represented in the cipher by another letter, which always remains the same, solution is made more or less easy by the application of the well-known rules of letter frequency. He points to the fact that, taking our own example for the purpose of demonstration, E, the most frequently occurring letter in the average English text, is represented at its first occurrence by I and on each of its subsequent eight recurrences by M, M, G, G, T, V, I and T in the order shown; T, the second letter in English in point of frequency, by I, V, V and B and so with the other letters of the plain-text whose cipher equivalents follow the same eccentricity.

How then—asks the incredulous one—can such an example be solved?

But before we proceed, let us return to the popular misapprehension, the delusion regarding the invulnerability of this system which is so firmly fixed that we come in contact with statements and articles describing it as "indecipherable" and some even refer to it as "new." I have in mind an article published in the Proceedings of the Engineers' Club of Philadelphia and reprinted in the Scientific American Supplement (No. 2143) of January 17, 1917, entitled "A New Cipher Code," in which our old and well-known Vigenère table appears as the subject of an interesting if somewhat erroneous article. The author's closing paragraph is of especial interest and is quoted herewith:

"The method used for the preparation and reading of code messages is simple in the extreme *and at the same time impossible of translation unless the key-word is known.* The ease with which the key may be changed is another point in favor of the adoption of this code by those desiring to transmit important messages *without the slightest danger of their messages being read by political or business rivals.*" etc.

The italics are ours!

A similar article, in Spanish, treating of the same system appeared in a weekly paper of one of the South American capitals (*VARIEDADES*, Lima, Peru, October 20, 1917). Similar claims were made as to the "indecipherability" of communications enciphered by the system under discussion.

That the conclusions of the authors of the respective articles are in error will be shown.

In any problem the first thing to engage attention is how it functions and then to reverse the process in the hope of undoing what has been done. How many of our readers are familiar with Poe's statement which is, in effect, that "what human ingenuity can do, human ingenuity can undo!"

Returning now to our example, after this divergence, we note that although given letters of the text are represented by a variety of other letters in the cipher when they are enciphered by different letters of the key-word, each letter of the plain text when enciphered by a given letter of the key-word invariably takes the same cipher equivalent. Note, for example, that C of the foregoing example when enciphered by the key-letter C is represented by E on both occurrences; S by U on both occurrences; E by G each time it occurs; R by T both times and T by V on each occurrence. This is, in effect, equivalent to the letters falling in this column being enciphered by the "C" of third alphabet. Likewise of the letters enciphered by the letter I of the key-word, I of the plain text is represented by Q on each of its three occurrences; E, which was represented by G in the preceding alphabet is represented by M on both of its occurrences in the present instance. Thus all of the letters enciphered by means of the key-letter I of the key-word, are enciphered by the "I" or ninth alphabet of the table and so on throughout the example.

Now since we know that all letters enciphered by means of the same alphabet or key-letter always take the cipher equivalent it must follow that if we can ascertain the number of alphabets employed (the number of letters in the key-word) we can segregate the letters of the cryptogram into as many groups and that each group will constitute in effect a simple substitution example. The plain-text equivalents of its constituent letters can, if there are sufficient letters, be found in the usual manner of solving cryptograms of this type, that is, by making a frequency table of the cipher letters and comparing it with a normal frequency table.

But how—we are asked—are we to ascertain the number of alphabets employed in enciphering the example—in other words, how are we to know the number of letters in the key-word?

Simply enough! But here we must fall back on some of the facts we have learned from the study of what we may term the mechanics of written language. In solving Poe's "Gold Bug" cipher we learned that the letter E represents approximately 13 per cent of the letters in any average English text; T approximately 9 per cent; O eight per cent and so on. A table of letter frequency for an ordinary English text of sufficient length to give a representative frequency, represented graphically, would assume the following appearance:

A ....
B ...
C ......
D ....
E ....
F ....
G ...
H ....
I ....
J .
K ..
L ....
M ......
N ....
O ....
P ....
Q
R ....
S ....
T ....
U ......
V ..
W ...
X
Y ....
Z

(This table is based on a check of text two hundred letters in extent.)

But in treating with Poe's example we did not learn—for there was no occasion in his example for its employment—that not only do the letters in written English (and all other European languages for that matter) occur with a given frequency, but that letters combine one with another, to form syllables, terminations and words with a given and known frequency. For example, note in any English text the frequency with which "the," "than," "that," "their," "theirs, "them," "there," "they" and words such as "fourth," "fifth," etc., having -th as their suffix, occur. Words like "other," "and," etc., etc., occur with considerable frequency and terminations such as "-ance," "-ency," "-ion," "-ment," etc., inevitably occur, and a check of "bigraphs" as these two-letter groups are called, gives the following results, the bigraphs shown in the order of frequency: TH, ER, ON, AN, RE, etc., etc. What has been said of bigraphs applies to "trigraphs" or three letter groups and to other letter groups as well and the trigraphs in their order of frequency appear as follows: THE, AND, THA, ENT, ION, TIO, FOR, NDE, etc., etc.

Thus, in any text of any length, there must inevitably ap-

pear recurrences of such groups of letters and since we have learned that given letters of the plain text enciphered by a given letter of the key-word invariably give like results in the cryptogram, it must necessarily follow that such common bigraphs, trigraphs, terminations and words will often be enciphered by the key-letters in the same sequence which will produce as a result, similar cipher groups throughout the body of the enciphered communication and from these recurring groups the number of alphabets employed can be fixed to a certainty.

From this point the process of solution may be best explained by example: Given the following cipher communication which, from previous knowledge we shall assume to have been enciphered by means of the Alphabetic Square or Vigenére Table:

IXAIC CZLDI OXAIC RWJFW VWYEM EKUPR AYYFC WAAIR HWASY NKTJR TWKDF EURRF EJLDC INLSX

The first thing that engages the eye of the expert in the foregoing example are the recurring groups AI, which occurs three times; AIC, which occurs twice and LD which likewise occurs twice. Counting the number of letters between such recurrences, always including one of the groups in the count (*i.e.*, counting from the beginning of one group to the beginning of the same group of letters on its second or subsequent occurrence) we have:

AIC to AIC, 10 letters $= 2 \times 5$
AI to AI, 10 " $= 2 \times 5$
AI to AI, 25 " $= 5 \times 5$
LD to LD 55 " $= 5 \times 11$

The key-word may contain 2, 5 or 11 letters but since 5 is the dominant factor it is probable that a key-word of five letters was used in enciphering the example and we proceed to divide the communication into groups, five in number, taking the first, sixth, eleventh, sixteenth, etc., letters for the first alphabet; the second, seventh, twelfth, etc., for the second alphabet; the third, eighth, thirteenth, etc., for the third alphabet; the fourth, ninth, fourteenth, etc., letters for the next alphabet and the fifth, tenth, fifteenth, twentieth, etc., letters for the last alphabet and when this has been accomplished a frequency table is made for each of the groups, which assumes the following appearance:

I	II	III	IV	V
A .	A .	A	A	A
B	B	B	B	B
C .	C	C	C	C ....
D	D	D	D ...	D
E ...	E	E	E .	E
F	F	F	F ..	F ..
G	G	G	G	G .
H .	H	H	H	H
I ..	I	I	I ...	I .
J	J .	J .	J .	J
K	K ..	K .	K	K
L	L	L ...	L	L
M	M	M	M	M .
N .	N .	N	N	N
O .	O	O	O	O
P	P	P	P .	P
Q	Q	Q	Q	Q
R .	R	R .	R .	R ...
S	S	S	S ..	S
T .	T	T .	T	T
U	U .	U .	U	U
V .	V	V	V	V
W .	W	W	W	W
X	X ..	X	X	X .
Y	Y .	Y ..	Y	Y .
Z .	Z	Z	Z	Z

While the example is a very short one from which to expect representative frequency tables, factors to aid us in fixing the plain-text equivalents of the cipher letters in each of the five alphabets: (1) The letter frequency and (2) what is known as symmetry of position, that is, the position of one letter in the alphabet with relation to the others, when it is known that normal or A, B, C, sequence alphabets were used (which is the case when the Vigenére table is used) thus, in the first table E plainly represents itself both by reason of its frequency and its relative position with respect to the other letters which are shown as having occurred in that alphabet. In the second frequency, W, for the same reason is plainly the equivalent of E in the plain text. In the third frequency A might equal E, being the most frequent letter, but in this event the other letters correspond to what we expect since in this event L, which occurs three times would equal P and we would hardly expect that number of P's in a text of fourteen letters so we change to the theory that A must represent one of the other frequent letters of the alphabet—probably T—and assume that L, occurring three times, is the equivalent of E which would then make A the equivalent of T, which agrees with what we have reason to expect. In the fourth table F equals E and in the fifth C equals E.

Turning now to the Vigenére or Alphabetic Square, we find that E equals itself in the first alphabet of the square; W equals E in the nineteenth alphabet; L equals E in the eighth; F equals E in the second and C equals E in the twenty-fifth alphabet. With this knowledge it is an easy matter to fix the values of the remaining letters of the five alphabets and the communication may be deciphered directly by reference to the alphabets in question, or by noting the equivalent of the letter A in each alphabet the key-word—a knowledge of which is not at all essential—may be ascertained and the cryptogram deciphered in the usual manner.

The key-word is ASHBY and the communication. deciphered, reads: IF THE CHECK OF THE RECEIVER DOES NOT AGREE WITH THE TRANSMITTED CHECK THE RECEIVER, etc., etc.

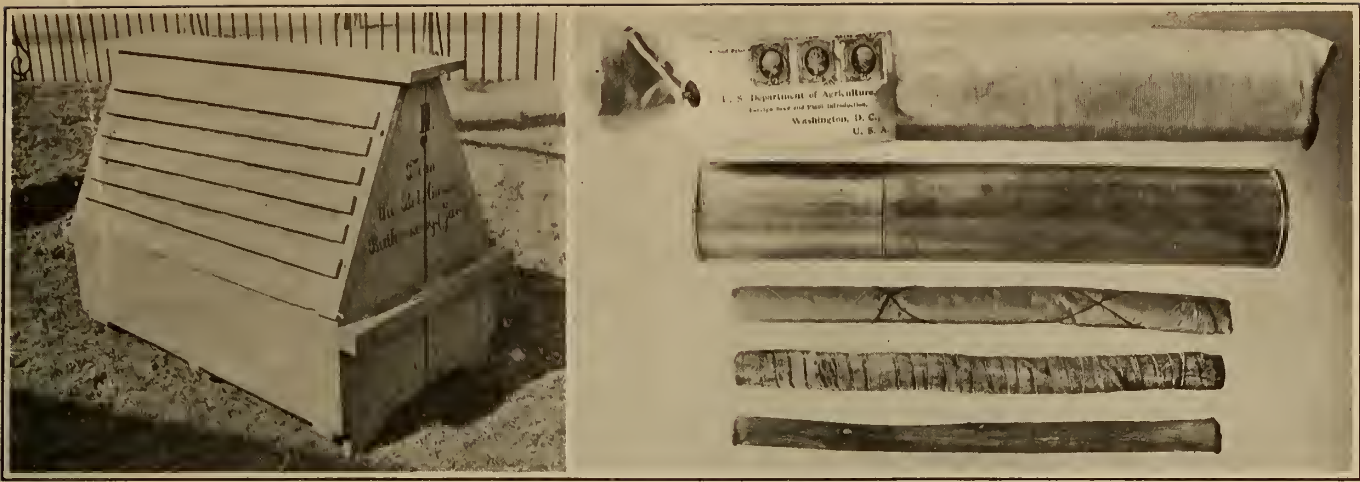
It may be claimed that the process of solution is labored or complicated but this is not so, it is comparatively simple and it must be taken into consideration that many of the steps gone into at length, for the sake of elucidation, are either ignored or performed almost mechanically under other circumstances.

This is but one of a number of methods by means of which ciphers of this type may be solved.

It may be frankly admitted that a very short, isolated communication enciphered by means of the Vigenére table may remain *undecipherable*, but one of any considerable length or a number of short communications enciphered by the same key would not long remain secret and since a practicable cipher must anticipate such employment, examples of this type would not perplex the expert for any great length of time.

TRAINING THE CHEMICAL ENGINEER

At the recent meeting of the Institute of Chemical Engineers the Committee on Chemical Engineering Education made a progress report, the statistics of which are given in full in the June 15th number of *Chemical and Metallurgical Engineering*. It is, indeed, surprising to find such a wide variety of subjects prescribed in the courses of some seventy-five educational institutions. The total number of different courses are something over two hundred and thirty and in the list one finds some rather unexpected topics as, for example, Irish history. There is no doubt that standardization is needed even though some of the institutions must offer specialties, as for example, sugar in Louisiana, paper in Maine, and ceramics in Illinois. The chairman of the committee, Dr. Arthur D. Little, 30 Charles River Road, Cambridge 39, Massachusetts, is desirous of receiving any communications relative to the subject as the committee wishes to continue its work and do what it can to improve the situation. Those particularly interested in the subject will do well to study the tabular matter in the article to which reference is made.



THE TRAVELING QUARTERS OF SOME OF OUR IMMIGRANT PLANTS

Left: Portable greenhouse packed for shipment of a large plant. *Right*: A sample cutting and the way it is put up and mailed to the Department of Agriculture

Plant Immigrants to the United States

Where They Come from and the Precautions That Surround Their Naturalization

By S. R. Winters

CONGRESS and the immigration authorities are wrestling with the problems incident to the restriction of the tidal wave of foreigners who disembark at Ellis Island lest the character and magnitude of the influx unduly disturb the melting-pot process of Americanization. Similarly, at Washington, the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, is cognizant of its responsibility involving strict supervision of plant immigrants admitted into this country. Laxity in preparing consignments of rare seeds and plants collected from the remote corners of the earth, thereby introducing a scale insect or parasitic disease, would menace the plant industry of America.

Pickled mumes from Japan; wild alfalfas from Chinese Turkestan and Siberia; dwarf almonds, cherries and apricots assembled in Russian Turkestan; bamboos and strawberry trees from the south of Shanghai; rare vegetables discovered in Portuguese West Africa; potatoes from New Zealand; grasses from the Mediterranean region; durum wheats from Russia—such, in brief, afford a glimpse of the wide ramifications of the explorer whose life is dedicated to wandering in unfrequented areas in search of plant life for culture in this country. All told, 51,000 specimens of seeds and plant cuttings for propagation have been introduced in America within a period of 22 years. The vastness of the collection, obviously, entailed the importation of hundreds of worthless plants and others whose value yet remains to be determined. Still others, where the process of experimentation has been unerringly applied, have established their intrinsic merits even beyond the expectations of the enthusiastic agricultural explorers. Durum wheats, rice, Sudan grass, feterita, alfalfas, grasses, citrus fruits and sorghums are notable illustrations, the brief recital of their names suggesting a wealth of plant life.

From the mule-drawn cart, laden with its cargo of rare plants, treking through the sandy deserts of Africa to the cosmopolitan life of Washington, with its modern facilities of transportation, is a far cry. Shipping imperishable products half-way around the world is a risky undertaking, to say nothing of consigning living plant material to a journey of thousands of miles. Seed, cuttings or scions, and rooted plants, are the media employed for introducing growth into the United States from the far-away places of the globe. The wild life which formerly characterized many of these plants lends further interest in the methods which involve their subjection, consignment, and subsequent submission to the taming process which they undergo hereabouts.

Seed is the easiest and safest way of contact between the native home of the parent plant and the country of its adoption, with thousands of miles intervening. Ripe, unmixed seeds are essential. They are dried, subjected to the influence of shade rather than a bright sunlight, and where it is impracticable to clean them in the field the renovating process is administered on their arrival in Washington by the seed-cleaning machinery of the Department of Agriculture. The vitality of seeds varies quite as widely as the mortality of the human family—they may die within a few days if dried out or retain their power of germination for a quarter of a century. Small-sized seeds, like grass, melon and vegetable seeds are shipped dry in sacks or envelopes. Chestnuts, palm and seeds of fruit trees—as well as other larger growths having oily kernels—are packed in slightly moistened charcoal, the latter preferably having been washed to remove the creosote. Sphagnum moss, which is barely moist, likewise answers this purpose. Mango and mangosteen seeds, and other short-lived varieties are subjected to a moistened mixture of half charcoal and an equal part of chopped moss. Seeds extracted from fruits are washed, the adhering pulp is removed, and the seeds are dried in the shade before packing in charcoal. Otherwise molds originating in the fragments of decaying pulp may penetrate the living seeds. The risks imminent from molding are lessened by washing the packing material in two per cent formalin and then sousing in boiling water.

Seeds are not easily obtainable and not infrequently they are untrue to the parent stock in their reproductive capacity. Cuttings and scions—the former consisting of roots and the latter products of grafting—are appropriated with varying degrees of success. They are judiciously selected with regard to the perpetuation of a vigorous growth, devoid of scale insects or disease spots that not only would retard their own development but probably menace other plant life. The diameter of the cutting varies, plantsmen admitting that large specimens carry better than slender ones. A cutting or scion is taken from a portion of the branch which has completed its first season's growth, having not yet attained two years of age. Deciduous trees and shrubs are robbed of their

offspring after the leaves, operating by gravitation, have clustered on the ground. Cuttings of soft-wooded plants, for instance geraniums, are frequently unable to withstand the brunt of long-distance journeys. Decay is a foe of tender offshoots. Scions of the orange or plants with evergreen leaves can be subjected to the captivity of the agricultural explorer at any season of the year.

The ingenious but frank postal official of the Washington, D. C., post office, who in cautioning the pre-Christmas patrons to "Wrap with Care if You Care a Rap," issued an injunction which has virtue in the transportation of plant immigrants. Verbally, the instructions of the Office of Foreign Seed and Plant Introduction may not be so emphatic, but in supplying mailing containers its directions to agricultural explorers are of a positive character. Tin tubes have proved most satisfactory as mailing containers. The tin is removed from the mailing bag, it is opened and the dry sphagnum moss displaced. The cap is filled with water up to a small hole in it, the contents then being sprinkled over the moss. The latter is mixed until a uniform degree of dampness is evident. The mixture is deposited at one corner of the waxed paper which is enclosed in the tin. Forthwith the cuttings or scions, from three to six in number, depending upon their size, are placed on the moss, covering them lightly therewith. The corner of the paper is folded down, the cuttings and moss are rolled in the paper just tightly enough to permit of their encasement in the tin, and the side corners of the paper are folded in under the roll.

One of the special obligations devolving upon the explorer in his quest of rare growth is to supply data for recording in printed form the description of the plant and any history concerning its culture. Consequently, at this juncture of the mailing procedure the name of the plant, its variety, designation, the date and locality where collected, are written on a slip of paper and incorporated into the roll. The package is then inserted in the tin, the cap is placed on, and the tin given quarters in a sack. Postage required is pasted on the tag which accompanies each tin. The latter does not exceed 12 ounces, or 350 grams, in weight, and the rate of postage is equivalent to one cent per ounce or fraction thereof. The name and address of the sender appear on each tag, which insures quick identification of the shipment when it reaches Washington. The tins are retained in cool places in transit on board the steamer. Labels on consignment bear the words "Foreign Seed and Plant Introduction, United States Department of Agriculture."

Plants uprooted bodily from the soil of their nativity for long-distance hauls and subsequent transplanting are shipped in a sort of portable greenhouse. They are too bulky to send by sample post and are, therefore, forwarded by parcel post, express or freight. The plants are dug without injuring the numerous fibrous roots, and are packed in a ventilated box. A small wad of earth is left around the roots in the case of evergreen plants; the roots of deciduous trees are deprived of the adhering soil, moss being entwined about them as a substitute. The tops are unhampered, save in freezing weather when a cloak may serve as frost protection. Each plant is rigidly placed in the box so that it will not have room for acrobatic stunts. Ventilation, to be sure, is essential. Several one-inch holes, penetrating the region where the tops of the plants have quarters, afford sufficient air if they are on all four sides of the box. Recognizing that rats are not strictly land lubbers, each hole in the box of plants is covered with a strip of wire screen as a deterrent to invading pests. Plant shipments must be kept cool in transit, the box being stationed in what is described as the cool room (not the cold-storage room), where a temperature between 35 and 50 degrees Fahrenheit is maintained.

A specially-constructed portable greenhouse has been designed for the long-distance transportation of tender tropical plants. A substantial wooden box, having a strong bottom, is elevated from the ground by short legs. Handles are equipped at each end. The roof of the miniature house slopes, being composed of two glazed sashes, one of which is hinged at the ridge pole, thus permitting its uplift like a box lid. The glass is safeguarded by durable slats, ventilation being afforded by two holes, one at each end of the box in the vicinity of the ridge pole. Wire netting is a covering for these holes. Plants having quarters in these portable greenhouses are given light by occupying places on the deck of the steamer. An awning is a protection from salt spray and the salt water used in scrubbing down the deck, dosages which are injurious to foliage. Not unlike cattle in transit, plant life has to be watered at least once a week during the journey. Damp cocoanut fiber as a packing, however, will minimize the water requirements of plants.


PEELING THE PHILIPPINE MANGO, NOW BEING GROWN IN CUBA AND SOUTHERN FLORIDA

Newly-imported plants, upon arriving in Washington, are subjected to rigid examination by inspectors of the Department of Agriculture. The surveillance of incoming plant specimens applies to rare budgets from diplomatic and consular officials as well as to new varieties of rice that have possibilities of contributing to the crop wealth of Texas and Louisiana. Smuggling is not countenanced, and the argus-eyed, white-aproned inspectors of Uncle Sam are tireless in their activities of detecting insects and parasites that would intrench themselves along with the vegetative growth seeking acclimation. An identification tag, as well as a history of the variety, quantity and origin of the material, are prepared for each package or container from abroad. Compilation of this information and preparing an inspection card precede opening of the nursery stock upon its arrival in Washington. Each introduction is numbered by the Federal Horticultural Board, supplementing the serial number previously assigned by the Office of Foreign Seed and Plant Introduction. Thus it is possible to keep tab on the particular specimen, both with respect to its performances in this country as well as in the old world.

Questionable seeds, cuttings, plants, buds, or bud sticks, or those harboring insects or diseases of any description, are either destroyed or subjected to disinfection and grown under observation in a specially screened quarantine greenhouse far

BRINGING IN VALUABLE FOOD PLANTS AND TREES FROM ABROAD

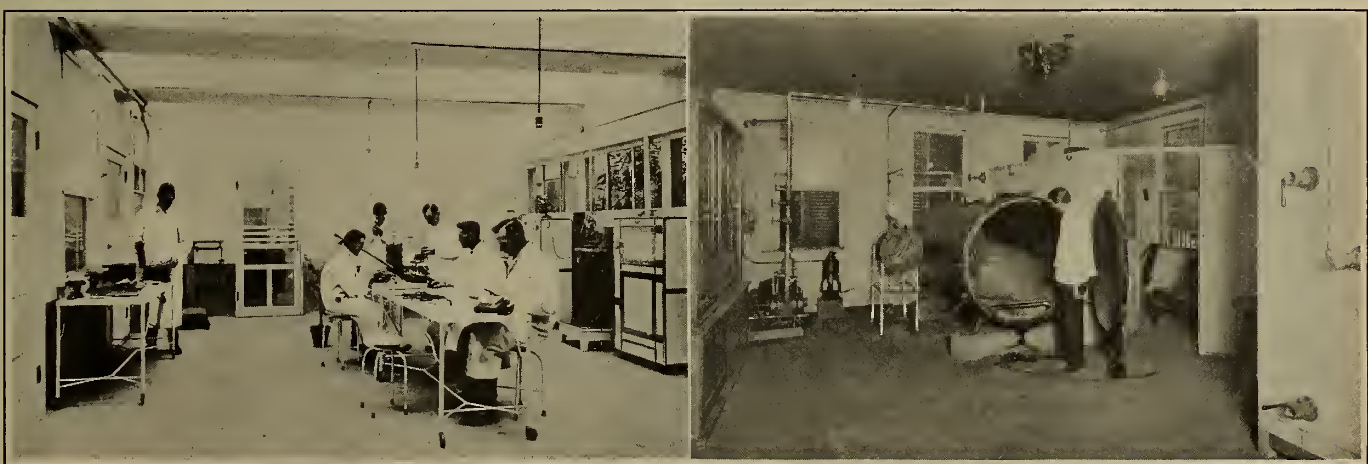
Left: A Chinese dwarf peach that produced seven fruits when but 15 inches high. *Right*: Inspecting plants that have been put under quarantine, to determine whether they may be freed of suspicion

removed from the area of cultivation. Other than periodical introductions of plants by the Office of Foreign Seed and Plant Introduction, there are other sources of importation which contribute to the duties of the inspection service. Diplomatic and consular officials, botanical collectors, travelers, missionaries, and amateur plant lovers abroad, seek admissions for their "finds" in foreign countries, ambitious of contributing to the plant industry of America. Seeds and bulbs are brought in for Congressional distribution, citrus plants and seeds are sponsored by the Office of Crop Physiology and Plant Breeding Investigations, and the Offices of Cereal Investigations and Forage Crop Investigations apply for admission in behalf of seeds of cereals and forage plants.

The necessity for inspection facilities is self-evident. The inspection house, maintained in Washington, is comprised of an inspector's office and room for examining the material. A high wire fence encircles this house, and the gates and doors are locked against outside intrusion. Special permits, expiring at the end of the day of issue, are given interested persons. The office of the inspector is 12 by 19 feet in dimensions, having three windows, two skylights extending the width of the room, and three doors, one of which opens into the inspection quarters. Furniture is conspicuously absent, only such units as those required to preserve the records being found. Nursery stock is not examined in this office.

Inspection of plant immigrants is negotiated in quarters 19 by 30 feet in size, the room having four windows, four skylights embracing the width of the room, eight ventilators, and four doors. The latter are screened with copper wire mesh, forty meshes to the inch. The floor and three feet of the walls are of concrete, while the remaining portion of the walls is constructed of galvanized iron. This manner of construction permits of flushing or syringing of the floor and walls with water or a disinfectant without harmful effects. Furnishings of the inspection quarters are more lavish than those of the inspector's office, including: Five white enameled tables on wheels on which are deposited specimens subject to examination, four white enameled stools, three white enameled refrigerators for safeguarding perishable plants, a small sterilizer, stove, sink for washing the hands, scales, and white enameled trays for sterilizing small portions of seeds or cuttings with bichloride of mercury, and one white enameled bucket containing a weak solution of bichloride of mercury for washing the hands after handling material suspected of being infected with insects or diseases. Long white coats are the distinguishing characteristics of inspectors, raiment invariably worn when inspecting immigrants of the plant world. Soiled coats are retained in a galvanized iron bucket until disinfected and laundered. Inspection quarters are daily cleaned and fumigated or washed down with formaldehyde as the demands may warrant.

Quarantine regulations of diseased plants are enforced with quite the precision that an attending physician would bring to the isolation of a patient inflicted with a contagious disease. Capacious is the quarantine greenhouse, being 70 feet long, 20 feet wide, and divided into 14 units, six of which are 14 feet by 7 feet 4 inches, and eight of which are 7 feet 8 inches by 7 feet 4 inches. A three-foot corridor extends the



MAKING SURE THAT NO PLANT PESTS ACCOMPANY THE PLANT IMMIGRANTS OVER OUR BORDER

Left: Room in which incoming material is examined to determine the presence or absence of disease. *Right*: Vacuum fumigating apparatus which gives some of the suspected plants a clean bill of health

length of the structure. Admission into a unit from the corridor involves passage through a vestibule 3 feet by 3 feet which is provided with two doors, one opening into the corridor and the other into the unit. Doors and ventilators are screened with copper wire. The ventilators are so arranged that they can be controlled from the corridor, thus obviating entrance therein for the purpose of regulating air chambers. Other than being screened, the ventilators open into the corridor and not directly out of doors. This arrangement is in the interest of protection of the plants from a strong wind and in making secure the insects whose discovery and effacement are to be accomplished according to scientific methods. Air is admitted in the corridor at the apex of the room by standard ventilators used on greenhouses. Adequate circulation of air is facilitated by equipping each unit with a small sliding window 10 inches by 16 inches, screened with copper-wire mesh. The sill of each window is eight inches from the floor. These various units retain their independence with respect to being fumigated separately. Object of quarantine, serial number, date of quarantine, name of specimen, origin, and prescribed treatment, are made the subject of permanent record.

The apparatus used for sterilizing plant and plant products consists of a fumigation chamber or retort, an auxiliary chamber or generator for the generation of gas and an air pump. One end of the chamber is permanently closed, while the other end is equipped with a stout iron door swung on a hinge and held in a fixed position by six clamps. The gasket, embedded in the door, comes in immediate contact with the flange of the retort and when greased and clamped is a bar to air entering the chamber during an exposure. This retort lies with its longest axis in a horizontal position. Four openings are in the upper side of the retort: The one nearest the door is provided with a vacuum gage, registering the degrees in pressure in units equal to inches of mercury; the second opening is fitted to an exhaust pipe which is attached to the air pump; the third opening is used to permit the air to enter the chamber at the completion of an experiment, while the fourth opening is fitted to a pipe which leads to the auxiliary tank or generator in which the gas is generated.

Plants and plant products to be fumigated are placed in the retort, the door closed and clamped, and the air exhausted until the gage registers 26 inches. Differently expressed, the air in the chamber is drawn out until the pressure is the equivalent of 5 inches of mercury. Here the suction is cut off, and the gas is generated in the auxiliary chamber and introduced into the fumigation chamber through a pipe. Gas may be generated in one of two ways. The cyanide may be placed in the jar within the generator, the door closed and the acid and water introduced through the tubulature; or the acid may be placed in the jar within the generator and the cyanide in solution introduced through the tubulature. Experience justifies the latter procedure as preferable. This is particularly true where a glass tubulature is employed, as it eliminates all possibility of breakage of glass by the heat generated from the combination acid and water. Material to be disinfected may be fumigated in either of two ways, namely, by generating the gas in the presence of a partial vacuum and holding the vacuum for a specified time, or by generating the gas in the presence of a partial vacuum and returning to normal atmospheric pressure upon the completion of the generation. Thus the possibilities of introducing a scale insect or parasitic disease that might menace the plant industry of America are minimized.

Historically speaking, how well has the plant immigrant assimilated itself in the melting pot of the plant industry of America? Only a few notable illustrations will be recited, the values of the plants enumerated being quoted as computations of the Department of Agriculture: Feterita, imported from Egypt in 1906, has an annual crop valuation of $16,000,000 in this country. Sudan grass, preeminently the forage crop of the South, has a commercial appraisement of $10,000,000. Durum wheats, products of Russia, made wheat production a factor in a hitherto non-growing area in the Northwest. The taxpayers were assessed a quarter of a million dollars to meet the expenditures incident to the importation, while the Department of Agriculture assesses the income from this investment as approaching $50,000,000, yearly. Navel oranges from Brazil gave to California its mammoth industry, involving the cultivation of 30,000 acres, a crop computed to be worth $15,000,000 annually. Bamboo groves, carpet grass, lespedeza, and alfalfa valued at millions of dollars, are cumulative evidence that plant immigrants are capable of acclimating themselves to plant life without being a disturbing influence in the seething melting pot of America.

SCIENCE AND COMMUNITY TRUSTS

In the June 10th number of *Science*, R. M. Yerkes calls attention to community foundations or trusts of recent origin which have considerable funds at hand for scientific service or for research. The Research Information Service of the National Research Council has recently compiled available information concerning funds for research and if the funds at present listed as community foundations be added to funds listed in the Bulletin above mentioned it appears that there are approximately five hundred million dollars in American funds available for research in the natural sciences. Dr. Yerkes estimates that for the encouragement and support of scientific research through medals, prizes, graduate and research scholarships and fellowships between forty and fifty million dollars is spent annually in the United States.

The community trust idea appears to have originated in Cleveland where it began in 1914. This trust has grown to a foundation of approximately one hundred million dollars either given or bequeathed and following Cleveland's lead more than forty other American cities have organized similar trusts. The effort is to assure great security of principal, flexibility in the use of income and the prevention of obsolescence. There are numerous instances in the United States to illustrate the folly of making charitable gifts with fixed objects. Attention is called to the action of Benjamin Franklin who set aside a sum of money in his will to be used for the maintenance and benefit of a certain type of artisan, numerous at the time but no longer existent. As late as 1909 a fund of four and a half million was left for the benefit of full orphan or fatherless girls under such restricted conditions that already the point has been reached where only 114 girls are being cared for whereas the funds are adequate to provide for nearly a thousand.

The following illustrative purposes are quoted from the Resolution and Declaration of Trust creating a New York Community Trust:

"(a) For assisting public educational, charitable or benevolent institutions, whether supported wholly or in part by private donations or by public taxation;

"(b) For promoting scientific research for the advancement of human knowledge and the alleviation of human suffering or the suffering of animals;

"(c) For the care of the sick, aged and helpless;

"(d) For the care of needy men, women and children;

"(e) For aiding in the reformation of (1) victims of narcotics, drugs and intoxicating liquors, (2) released inmates of penal and reformatory institutions, and (3) wayward or delinquent persons;

"(f) For the improvement of living and working conditions;

"(g) For providing facilities for public recreation;

"(h) For the encouragement of social and domestic hygiene;

"(i) For the encouragement of sanitation and measures for the prevention of disease;

"(j) For investigating or promoting the investigation of or research into the causes of ignorance, poverty and vice, preventing the operation of such causes, and remedying the conditions resulting therefrom."

The Size of the Galaxy*—II

New Results from a Study of Star Clusters and the Structure of the Universe

By Harlow Shapley, Ph. D., Mount Wilson Observatory

III. ON THE DIMENSIONS AND ARRANGEMENTS OF THE GALACTIC SYSTEM

IN the first article of this series we have discussed the scope and adaptability of those methods of measuring uncommonly great sidereal distances that involve the luminosity of particular types of stars. We have passed from this to a general description of a typical globular cluster for which the distance has been measured by the new methods. Having thus learned something of their great dimensions, something also of their internal organization which appears quite independent of our stellar system or of any other external mass, we are lead to inquire whether these gigantic globular clusters are sidereal "universes" comparable with our own. Our studies show their richness in stars of normal types, their enormous distances from the sun, and their isolation in space. Their flattened form simulates our own galactic concentration of stars; while in frequency of colors and magnitudes, the conditions in distant clusters do not appear to differ greatly from conditions in the solar neighborhood.

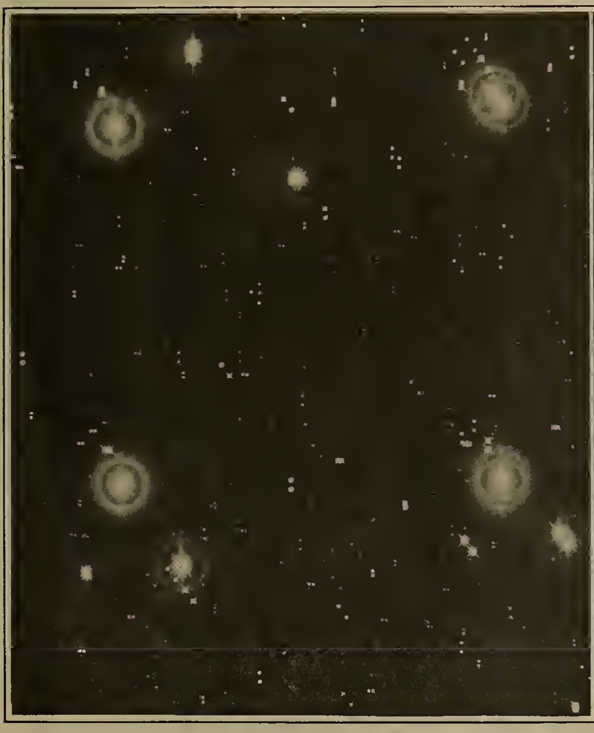
Certain difficulties, however, stand in the way of accepting the hypothesis of close similarity to our stellar system, and these difficulties lead to a closer study of the relation of globular clusters to the general sidereal conglomerate that we call the Galaxy. In the first place, the condensation of stars at the center of a globular cluster is incomparably greater than that around the sun—and the sun has heretofore been thought to be near the center of the known stellar universe. Second, the globular clusters are concentrated to a point in the southern Milky Way, suggesting some sort of relationship to and dependence on the central plane of the galactic system. Third, some investigations of the colors and probable distances of the faint stars of the Milky Way indicate that the dimensions of the galactic system are really much in excess of the usually accepted values, and therefore that the globular clusters are relatively too small to be treated as close analogues.

The inquiry into the possible significance of a globular cluster in the general sidereal scheme has naturally proceeded from the detailed analysis of two or three of the brighter objects to a comprehensive investigation of the distances and distribution in space of all known globular clusters. The completeness of our material is a great advantage in this study; it means that the time is opportune for a consideration of the total assemblage of globular clusters—that conditions now favor a search for signs of organization and relationship among these four score cosmic units.

The methods and observational work involved in the determination of the distances need be reviewed but briefly in this place, omitting discussion of the details, which are mainly of technical interest. The presence, in some clusters, of Cepheid variables of known period and brightness permits accurate measurement of distance, thanks to the valuable characteristic behavior of Cepheid stars. Correlation of the brightness of the variables with the brightness of other stars that are always present in globular clusters, extends to clusters without variables; this photometric method of measuring distance and the correlation of these distances with apparent diameter and with total brightness yield simple means of estimating the distances of all globular clusters prior to knowledge of variability or brightness of their individual stars. Much observational work has been necessary to establish definitely whether or not certain faint objects are globular clusters; and for the objects too far south for study at Mount Wilson, photographic records from other sources have been used.

From such analyses we have finally obtained values of the distances of eighty-six objects, all but a few of which are known certainly to be globular. As the coordinates of these clusters on the celestial sphere are accurately known, we

*Adapted by the author from a series of articles published in *Scientia*, October, November, 1919, February, March, 1920.

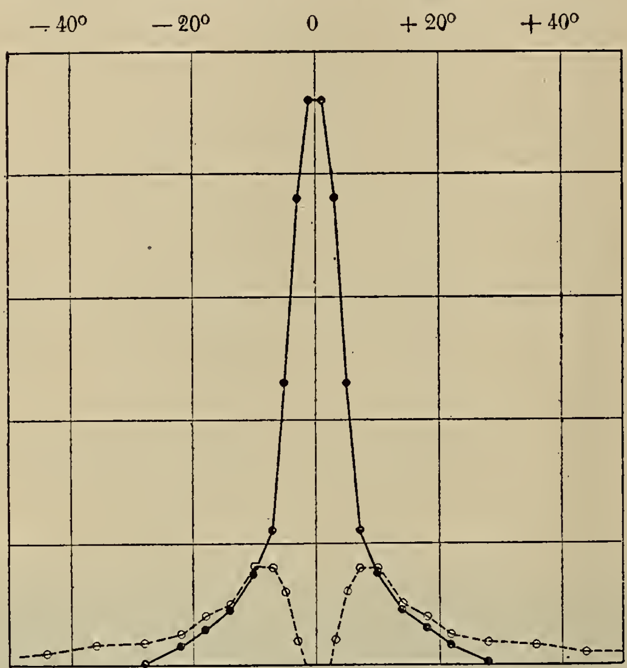


THE PLEIADES—A DETAIL IN PHOTOGRAPHIC PHOTOMETRY OF STARS

THE MOST DISTANT OBJECT NOW SHOWN IN THE UNIVERSE—THE GLOBULAR CLUSTER N.G.C. 7006

easily derive the positions in space of them all, and may plot these positions in three dimensions and study the result.

The Distribution of Clusters.—It has been known for many years that globular clusters are distributed in a peculiar manner. They are almost completely absent from one-half of the sky. North of the celestial equator there are about a dozen, nearly all of them bright and relatively near. South of the equator they are numerous, particularly in constellations along the Galaxy—in Scorpio, Sagittarius, and Centaurus. In that region some are bright, others are very faint and distant. They have an apparent affinity for the Milky Way, becoming more numerous as the galactic circle is approached from either side. It has been generally thought that they are concentrated in the ordinary way to this fundamental plane, presumably with maximum frequency at the center of the Milky Way, as is the case for many types of stars. A closer examination of the distribution, however, shows that these spheroidal systems, in striking contrast to the open clusters, are not most frequent at the galactic circle. Indeed they are completely missing from the middle part of the galactic belt—scarcely one within five degrees of its central line. Their greatest frequency is some seven or eight degrees from the plane



DISTRIBUTION OF SPHEROIDAL SYSTEMS (BROKEN LINE) AND GLOBULAR CLUSTERS (SOLID LINE) NEAR THE GALACTIC CIRCLE

of the Milky Way—a maximum on both sides, but a conspicuous minimum at the galactic circle. There are twice as many open groups, as globular clusters, but they are nearly all within the mid-galactic belt, ten degrees in width, from which globular clusters are absent.

The pronounced increase in the number of globular clusters, as the galactic circle is approached from either side, and the still more remarkable abrupt decrease in the number, just as the densest stellar regions are attained, suggest that here we have a phenomenon of high importance. Notwithstanding their great distances from the sun, and from each other, we must conclude that the plane, with respect to which they are symmetrically arranged, is none other than the plane to which the nearer open clusters congregate, that is, the galactic plane, which is also a fundamental factor in the distribution of stars of all types, of star clouds, and of various kinds of nebulæ.

The System of Globular Clusters.—The nearest globular system, Omega Centauri, is some 20,000 light-years away—a distance that is about fifty times the greatest that has been successfully measured by direct trigonometric methods, a distance several times the radius formerly assigned to the whole galactic system. Some of the other well-known bright clusters have distances in light-years as follows:

47 Tucanæ	22,000
Messier 22, in Sagittarius	27,000
Messier 13, in Hercules	36,000
Messier 3, in Canes Venatici	45,000

The distances of more than twenty-five globular clusters are in excess of a hundred thousand light-years; some distances approach the double of that value; and one remarkable system in the constellation Delphinus appears to be 220,000 light-years from the sun. This object, N.G.C. 7006, has been specially studied at Mount Wilson, and in the numbers, colors, and absolute luminosities of its stars it appears to be very similar to Messier 13 and Messier 3.

Viewed as a whole, the globular clusters form a great, roughly defined, spheroidal system, symmetrically divided by the plane of the Milky Way. Along the galactic plane the system appears to be at least three hundred thousand light-years in diameter; perpendicular to the plane it is irregularly and indefinitely limited to about half the foregoing value.

Remembering that their equatorial planes evidently are identical, we infer that the galactic system and the assemblage of globular clusters are coextensive, and that the center of the two systems may be the same. As a working hypothesis that appears to conform completely with the observations now existing, we may propose that the globular clusters are a part and show the outline of an immensely greater organization, in whose dynamic structure the plane of the Milky Way is a fundamental circumstance.

Is the Galaxy Composed of Clusters?—In this paper we are chiefly concerned with the light thrown by recent studies of clusters on the arrangement and size of the galactic system; hence we shall only briefly suggest that the new results also afford ground for discussion of the origin and present behavior of the sidereal system. There appears to be good observational evidence, and some dynamical reasons as well, for considering the galactic system as a mixture of star clusters, in all degrees of disorganizations, and for supposing that it may have originated in the combination of clusters. It may have grown, as it appears to be growing now, by the accretion of other stellar systems. It appears to be an example on a cosmic scale of survival of the fittest, that is, survival of the massive and most stable.

Between the open and globular clusters relationships exist other than the complementary distribution. The spectroscope, in the capable hands of V. M. Slipher, has shown that many, perhaps most of the globular clusters are falling with enormous velocities into the galactic region.[1] Hence we may place some confidence in the hypothesis that the globular systems, in some manner as yet undetermined by observation or theory, are ultimately transformed into the open galactic clusters whose massive stars for a long time withstand the tendency to disintegrate. There is also evidence (1) that stars throughout extra-galactic space are commonly organized into these uniform globular units, (2) that the spiral nebulæ represent a different kind of generalized sidereal unit, and (3) that the flattened galactic system as a whole is moving through space.

We see as yet no evidence of external galaxies comparable at all with our own. Possibly they exist; the supposed motion of the galactic system suggests the attraction of an enormous mass; but neither the spiral nebulæ nor the globular clusters appear to attain this grandeur of extent and power. As a single organization, the greater galactic system appears to rule throughout the whole of the sidereal universe that we thus far have explored.

We may summarize by stating that recent study of stellar distances has shown that in volume the galactic system is many thousands of times larger than formerly believed. We have found that at a distance of some sixty thousand light-

[1]It shows with even more certainty that the spiral nebulæ are rushing away from this region with still greater speed.

years from the sun, in the direction of the rich star clouds of Sagittarius, lies the center of the galactic organization. The most striking feature of the galactic system, besides its dimensions and probable mass, is the extensive, much flattened, mid-galactic segment, which contains open clusters, isolated stars, and nebulæ in abundance, but is devoid of globular clusters. Whether the absence of recorded globular clusters is due to some dynamical cause or to obscuration by dark nebulosity we do not know. Apparently the globular groups are approaching the segment from without—their radial motions, their distribution in space, and their probable genetic relationships to open clusters support that view. It may be that all the thousands of suborganizations in the galactic system—such as open clusters, star streams, moving groups like those in Ursa Major and Taurus, wide pairs of stars of common motion, long-period visual binaries—originate in these in-falling globular clusters; the galactic system itself, which appears to be little else than a great mixture of disintegrating minor systems, possibly owes its beginning and subsequent growth to globular clusters.

But whatever its origin and destiny, it is clear that the sidereal system is a giant in mass and volume compared with the region around the sun to which we have usually confined our stellar investigations. The interpretations of the greater system, however, will rest largely upon our knowledge of the motions and other characteristics of the nearby stars. It then remains for us to consider from a somewhat novel point of view this local group, which is so important in all our stellar studies.

IV. THE SECONDARY GALAXY AND THE LOCAL STELLAR GROUP

In studies of neighboring stars—those within a region which we may designate as the solar domain—we on the earth have a few distinct disadvantages. In some respects we are too close to our problem. We are too much involved in the minor movements, too much confused, in the bewildering mixture of sidereal bodies, by the unknown or poorly known relations connecting number, distance, spectrum, motion, and brightness. We are confined to a rotating, revolving planet in a moving solar system, which is related in some unknown manner to surrounding stellar organizations, and these also probably rotate and revolve around unknown centers of mass.

Much as the form, extent, and maneuvers of a marching army are better known to the aeronautical observer high above than to the soldier in the ranks, so might our analysis of the solar domain be clarified if we could view it from a distance. The marching soldier would surpass the flying observer in knowledge of the equipment and physical appearance of himself and of a few surrounding soldiers; the terrestrial astronomer would surpass an observer a thousand light-years away in knowledge of our planetary system and of the astrophysical properties of a few neighboring stars. But to decipher the structure and behavior of the army as a whole would be laborious and uncertain for the soldier in the ranks—and the experience of two thousand years has shown how difficult the analogous problem is for the earth-bound scientist.

Our present knowledge of the Hercules cluster, Professor Eddington has remarked, is probably greater, in spite of the enormous distance, than it would be if our solar system were in the cluster's midst. Possibly the greatest advantage of an external position, in the study of the stars of a stellar group, is that all members of a distant compact organization may be considered as equally remote from the observer (the small error committed by this assumption is easily computed), and measures of apparent brightness and motion may be used directly as indicative of actual luminosity and motion.

Let us imagine an observer, situated on a planet physically similar to the earth, at the nearer edge of the Hercules cluster, and let him be equipped with all our modern astrophysical apparatus, with our present scientific knowledge and a capacity for further instruction. From this remote observing station, far outside the star-populated galactic regions, let us, in imagination, view with him the sun and its stellar neighbors. Perhaps from this viewpoint we may gain a clearer idea of the relation of our own local star to the stellar universe, and learn how large a part is played in the galactic scheme by the familiar circumsolar domain.

We call to mind, in the first place, that the observer in the cluster would now be analyzing light of the epoch 34,000 years before Christ, because the light emitted since that time by our own sun and neighboring stars has not yet reached his part of space. That is no serious objection, however, for meanwhile the sidereal system has probably altered in physical aspect only in minor details, such as the comparatively small changes in relative positions and the coming and fading of Novæ. But in another respect our choice of observing station is not happy: our sun would be inconspicuous to a humiliating degree. It would, in truth, be of the twentieth magnitude in visual light, which is less than a tenth as bright as the faintest star that has ever been seen with the greatest telescopes.

To get our sun and similar dwarf stars into his catalogues, we shall bring the hypothetical Herculean observer ten-elevenths of the way from the cluster to the earth. His station is then at a distance of 3300 light-years, and for him Sirius, an eleventh magnitude star, is separated a twelfth of a degree from the sun, a star of visual magnitude 14.8.

For many years we have been aware of the decrease in number of stars per unit of volume with increase of distance from the sun. Naturally this has been taken to indicate that the stellar system is mainly limited to a thousand light-years or so, and that our sun is near the center of the stellar universe. Recent research has verified the thinning out of stars, not only in high galactic latitudes, but also in the direction of the Milky Way. Hence, the Herculean observer from his new observing station does not see a uniformly populous stellar field around the sun; rather, he sees a stellar assemblage that in density of stars diminishes gradually from a fairly rich center, not far from the sun, to a relatively low density at the perimeter, some twenty or thirty degrees away.

He does not, however, see a complete termination of the whole stellar system a few thousand light-years from the sun, if the interpretation of the Galaxy, given in the preceding paper of this series, is even approximately right. The real galactic system, the greater part of which appears to us in projection as the belt of excessively faint Milky Way stars, appears to the Herculean observer as a stellar cloud, completely filling one-half of his sky and constituted of millions of scattered stars and hundreds of open groups, our solar domain being the most conspicuous group because of its nearness to his station.

The B-star Cluster.—In an important paper on the structure of the Galaxy, published four years ago, Professor Charlier showed that the bright stars of spectral type B form a flattened cluster, apparently about four thousand light-years in greatest diameter.[1] Since the analysis showed that the size, form, and orientation of this special stellar assemblage agreed well with earlier inferences from other sources relative to the whole of the galactic system, the B-type organization was identified by Charlier with the sidereal universe—that is, the bright B-type stars gave "what might appropriately be called a skeleton image of the Milky Way." More recent research has shown, however, that many B-type stars exist far beyond the limits assigned to this special group, and also that the local group is small in comparison with the galactic system as made known by stellar clusters; but still the evidence of a definitely limited circumsolar cluster of B-type stars remains, and a little consideration shows that it really outlines the same "universe" of stars that previous investigators had inferred from the decreasing stellar density with increasing distance from the sun.

It seemed best, therefore, to re-examine Charlier's material and similar data from the point of view of the larger Galaxy.

[1] *Comptes Rendus*, *162*, 872, 1916; Meddelanden fran Lunds Astronomiska Observatorium, Series 2, No. 14, 1916.

We shall not discuss here the methods, details, and lesser results of a rather extensive investigation. The principal results include the demonstration that the central planes of the system of bright B-type stars and of the galactic system do not coincide, and this lack of coincidence becomes at once the strongest proof of the actuality of a distinct local organization. The open clusters, the globular clusters, the galactic Novæ, the Cepheid variables, the star clouds—classes of objects extending far beyond the bounds of the solar domain—all define one and the same plane; they all appear symmetrically distributed with respect to the generally accepted galactic circle. But we now find that the brighter stars of spectral types B and A (and we infer that the same holds for all stars of the local cluster) are symmetrically organized about a plane that is inclined between ten and fifteen degrees to the galactic circle.

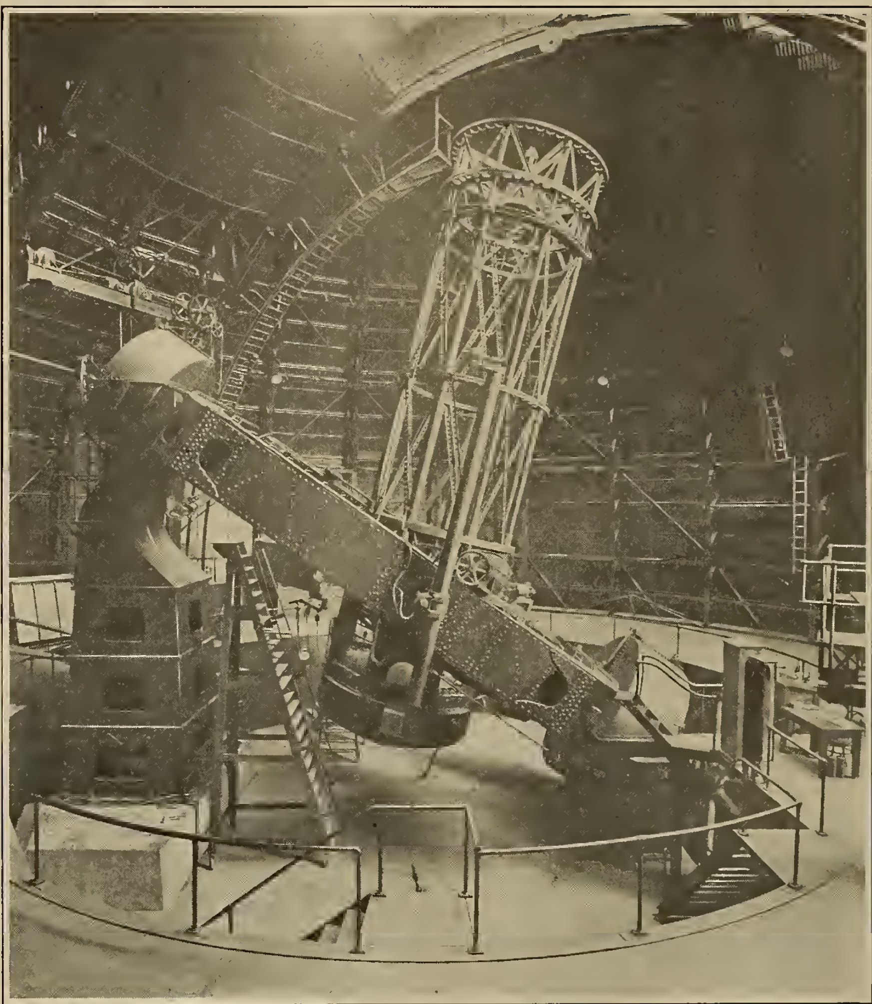
The small inclination has undoubtedly helped to conceal the existence of the local group, much the same as the position of the sun not far from the center has led us to limit erroneously the whole galactic system by interpreting as a universal rather than a local phenomenon the decrease in star density with distance.

From several lines of evidence we find that just beyond the limit of the local cluster there is also an abundance of stars — members of the general galactic fields; and from this fact, and from various observational results concerning the nearer stars, we infer that galactic stars and cluster stars are thoroughly intermingled throughout the whole extent of the local group, the field stars becoming proportionately more numerous with increasing distance from its center. It appears probable that some of the smaller moving groups, *e.g.*, the Ursa Major system, are interpenetrating clusters of the field, independent of the much larger local system and in structure and motion essentially undisturbed by it.

Some stellar types are much more frequent in the cluster than in the field, and a study of their distribution and motions gives us results directly applicable to the cluster alone. Other types such as the Cepheid variables and the planetary nebulæ appear to be almost exclusively members of the field, and they are of service in orienting the cluster and in studying its motion as a whole. But most of the normal types of stars are probably common to both field and cluster, and the study of either the cluster or the field on the basis of our knowledge of such stars will be attended with obvious difficulties and uncertainty. To the observer at the station one-eleventh the way to the Hercules cluster, however, the analysis of content and extent would present no serious obstacle.

We must regard as preliminary many of the results so far obtained relative to the local cluster, but a few points not mentioned above seem definite enough to be enumerated with brief discussion.

(a) B-type stars are near the plane of the secondary Galaxy even at a distance of some 1200 light-years from the sun, but are quite absent in high galactic latitudes. The local cluster accordingly appears to be very flat so far as blue stars are concerned, and is probably much larger than the typical open clusters of the galactic segment. In dimensions it possibly approaches the Magellanic Clouds or some of the more sharply defined of the star clouds of the Milky Way.



INTERIOR OF THE DOME, MOUNT WILSON OBSERVATORY, SHOWING THE 100-INCH TELESCOPE

(b) The center of the local cluster is between two and three hundred light-years from the sun (in the direction of the constellation Carina), according to Charlier's determination. My later investigation suggests that his value of the distance may be at least a hundred light-years too large.

(c) It is not clear now, and may never be certainly known, whether our sun is a field star or a member of the local cluster which includes a majority of our brightest naked eye stars. The sun may have originated when and where the other stars of the cluster began their careers. On the other hand, as a field star, it may have no relation to the cluster. In that case it would be only a matter of fortune that during man's term of existence on the earth his night skies have been brightly illuminated by a great group of drifting stars unrelated to our own luminary.

A Secondary Milky Way.—As stated above, the local cluster is a very oblate spheroid, and some classes of stars appear to be strongly concentrated to its equatorial region. Perhaps the most remarkable effect of our position not far from its central plane is that the position of the cluster stars on the surface of the sky gives rise to what we may call the secondary Milky Way. The primary Galaxy chiefly owes its appearance to the projection on the surface of the sky of the thousands of millions of stars that exist in the galactic segment. The secondary Galaxy owes its lesser but distinctly perceptible tracing across the sky to the considerable extent of the local cluster along its own central plane and to the resulting apparent concentration of a majority of its stars to a narrow belt.

Though the secondary Galaxy is well defined by star analyses throughout its complete circuit of the sky, to the naked eye it is most clearly seen where it stands out some ten to twenty

degrees along the west side of the Milky Way—from Perseus southward through Taurus, Orion, and Canis Major to Puppis and Carina. Not only the very bright stars of types B and A throughout this region are to be assigned to the cluster, but also the rich belt of stars with magnitudes from three to seven. On the other side of the Milky Way from Orion and Canis Major, at the same distance from the galactic circle, we find in Cancer and Hydra no counter-part of this richness of naked eye stars; and the interjacent constellation Monoceros is almost destitute of stars brighter than the sixth magnitude, though it lies along the central line of the Milky Way, and is surpassingly rich in telescopic stars of the far-extending galactic segment. It is this distribution of bright stars, now attributed to the orientation of the local cluster, that long ago led Sir John Herschel, and later B. A. Gould, to point out that the most luminous stars of the sky define a belt that is not coincident with the Milky Way.

If we could look at the local cluster from the hypothetical external position, might it not be possible to solve some problems of the remarkable community motions of the brighter stars—Kapteyn's two star streams and similar systematic drifts? Possibly we have made a real advance toward the solution through our imaginative view from without, that is, through the conception of the solar domain as a suborganization situated in the heterogeneous fields of stars and clusters of the galactic segment. The flattened form of the local cluster suggests an internal motion of its members analogous to rotation; and the chance that the cluster also moves as a whole is enormously greater than the chance that it is completely at rest with respect to the surrounding and intermingling galactic field. When the local cluster moves the inevitable result is star-streaming—a preferential drift in the direction of the cluster's motion for cluster stars, and in the opposite direction for stars of the field. Superposed upon this true stream motion there should be a pseudo-stream motion, due to the rotational or oscillatory movement of the individual stars with respect to the cluster's center of mass.

Much evidence relating to the preferential motion of the stars appears to be in full agreement with this hypothesis of star-streaming, but as yet we cannot definitely say what part of the observed systematic drifts should be attributed to the motion imposed on the cluster by the galactic system, and what part should be attributed to the internal individualistic behavior of the cluster's stars.

FERROCERIUM AND THE OTHER PYROPHORIC ALLOYS

It was in 1903 that Welsbach discovered that certain rare earth alloys, when rubbed with a file, emitted brilliant sparks, which were able to ignite combustible gases. A few years later it was found that the best results could be obtained by the admixture of 65 parts per 100 of iron. These alloys have an action, similar to that of flint and steel, but the spark can be produced more easily than with the ordinary tinder box of gone-by days.

The mixture of rare earths consists principally of cerium, lanthanum, didymium, neodymium, praseodymium and samarium. All these metals are white in sunlight; their ordinary color is yellow and they oxidize with difficulty in air.

The mixture, which the Germans call "misch metal," possesses properties which vary according to the way in which the product is manufactured. One alloy, coming from a large chemical factory, is very malleable, while another, made by a plant working with an electric reduction method, is very hard and very brittle. The fragility is attributed to the presence of silicon among the impurities.

While the original pyrophoric alloys, made by Welsbach, contained about 40 parts per 100 of iron, the present day products contain only 15 per cent iron, but about 2 per cent bismuth or antimony are added in order to make the alloy hard. Silicon is found in all the ferrocerium alloys, partly because it is present in the original crude metal and partly because the crucibles used in the manufacture are made from clay. About 5 per cent of copper is added by certain plants in order to produce a pyrophoric alloy with not too high a melting point.

The pyrophoric property of these alloys is explained according to various theories. Some authorities say that this peculiar property is due to the presence of nitrides in the ferrocerium; others say that hyrides or suboxides are responsible for this action. No theory, however, has been confirmed by actual experience.

Certain of these alloys, made with mercury or platinum, which, however, possess no industrial interest, because of their price have been found to be very explosive. A platinum alloy, containing 25 per cent of the metal, has some of the well-known properties of the ordinary ferrocerium. The alloys made from zinc and cerium are particularly interesting because of their use in the illumination of the lamps used in mines. Those containing borium and cerium are also very useful for this purpose. A very fragile and easily pulverized alloy is obtained by the addition of 25 per cent of aluminum or magnesium to the ferroceriums.

The lower grade pyrophoric alloys which contain a high percentage of carbides are very unstable. They must be protected from the air by a coating of oil; otherwise they will be oxidized very readily and speedily become totally useless.

The raw materials that are used in the manufacture of the ferrocerium alloys are obtained generally from the residues recovered in the process of making incandescent mantles from monazite sand. After the thorium has been extracted from these sands, there remains a residue of the oxides of the rare earths, which is known by the name of "misch." The majority of the plants making these alloys produce ferrocerium by the electrolysis of the anhydrous chlorides of cerium, lanthanum, didymium, etc. An attempt has been made to use the fluorides of the metals of the cerium group, but poor results have been obtained thereby. Instead of a solid mass of the "misch" metal as is obtained with the chlorides, a thick pasty product is procured which cannot be used.

The electrical process of manufacturing ferrocerium requires cheap current. The crucibles are generally made from graphite or clay and are provided with large iron cathodes. Sometimes iron crucibles are used which have double walls so that they can be cooled by means of a current of water.

In the early days of this industry, the small pyrophoric stones that were sold were just little fragments of metal weighing only a quarter to a fifth of a gram. They were more or less scientific curiosities. At the present time there are to be had different types of tinder boxes on the market.

In one of these the pyrophoric alloy is made in the form of a small stick against which a small wheel made of hard steel rubs, the surface of which is striated just like a file. When the wheel turns, a shower of sparks is formed, which are directed against a cotton wick soaked in gasolene or benzine, causing it to ignite. Another type of tinder box has a long rod of the pyrophoric alloy which is scratched by a sharp point of hard steel. The sparks impinge on a thread of asbestos, soaked in gasolene. When the point is not in use, it is lodged in a small chamber in the apparatus.

The great market for the ferrocerium alloys in the United States is for the manufacture of the automatic gas lighters, while in Europe where the match industry is a state monopoly, its principal consumption is in the manufacture of tinder boxes. —*Rev. Chim. Ind.*, 1921, 88-89.

THE HANDLEY PAGE SLOTTED AEROFOIL

A paper read by the inventor before the Roy. Aeronaut. Soc., Feb. 17, 1921, describes the results of experiments on slotted aerofoils of various designs. The increase in lift coefficient possible with the slotted aerofoil permits either of slower running speeds than at present or, alternatively, of less power at top speed. At top speed it is possible to work at lift coefficients of between 0.2 and 0.3.

A TYPICAL COLLECTION OF PATHOGENIC BACTERIA FOUND ON FRENCH PAPER MONEY

Dirty Money and Disease

Happy Homes for Dangerous Germs in Worn-Out Banknotes and Coins

By Jacques Boyer

EVER since the teachings of the great Pasteur gave an entirely new slant to our ideas of disease thoughtful persons have been disturbed by the evident danger of the propagation of infectious maladies by means of objects which pass from hand to hand among the general public. There are numerous facts which prove that the germs of certain maladies are transmitted, for example, by means of books, bank notes, and gold, silver, nickel and copper coins. How many volumes, for instance, might not be contaminated by a tuberculous patient, constantly coughing, sneezing and spitting during the last months of his life? What huge numbers of microbes, of Phycomycetes, of microscopic algæ, and of the spores of the Mucorhinea or molds, paper money and small coins are liable to accumulate in the course of their travels from pocket to pocket among peasants, laborers, and even among citizens of the better sort! The fears of the hygienists are only too well founded at the present time, in view of the repulsive dirtiness of the small bills found nowadays in general circulation.

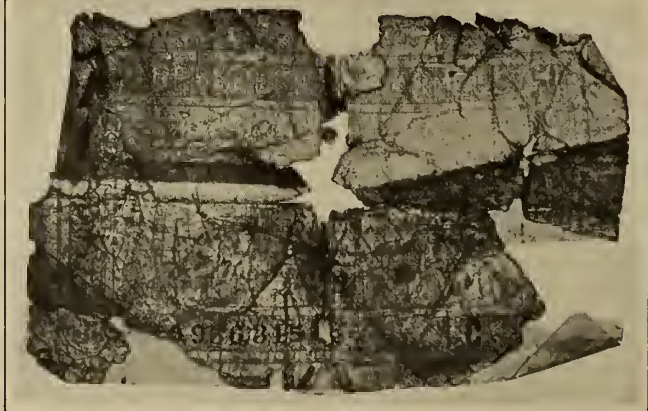
The microscope reveals to our startled eyes a frightful number of bacteria and of molds within the folds of the *filthy rags* which we are often forced to use as money, some of which, moreover, often have their pieces pasted together with strips of gummed paper. Moreover, these small bills rapidly deteriorate from the very fact of their intensive circulation. Like the Wandering Jew, paper notes of low denominations never rest upon their travels, whereas their rich cousins, the big bank notes. enjoy a period of repose from time to time within the bill-folds of the well-to-do, or the strong boxes of financial establishments.

While we wait as patiently as we may to have these disgusting bits of paper replaced by handsome coins . . . let us make a closer study of these invading micro-organisms and of the means employed to destroy them.

More than 30 years ago the Hungarian botanist, Jules Schaarschmitt, detected the presence of abundant cryptogamic vegetation (Schizomycetes, Saccharomycetes (yeasts) Algæ, etc.) as well as of a number of microbes, mingled with the débris of starch, of linen or cotton fibers, of fragments of hair and other organic matter, upon paper money. At about the same time Prof. Rainsch d'Erlangen likewise discovered the presence of various algæ and bacteria upon copper, silver and gold coins issued by various European governments.

We, ourselves, have likewise examined a certain number of small French notes of a much worn character, and can, therefore, give our readers direct evidence as to their condition. Furthermore, any one who reads these lines may verify most of our experiments, provided he happens to possess a microscope having a magnifying power of from 250 to 300 diameters.

Take a needle or scalpel and slightly scratch one of the dirty spots upon a worn bank note, then place the fragments thus obtained in a drop of pure water resting upon the object glass of a comparatively powerful microscope. Within the material taken from bank notes, even those which are least soiled, the observer will find a number of varieties of Saccharomycetes (including brewers' yeast and various other yeasts), great numbers of microscopic algæ and bacteria(micrococcus), various bacillæ, especially the *bacterium terna*, which is the agent of putrefaction and the *Leptothrix buccalis*, a parasite which is particularly abundant upon the tongue, in the saliva, and within the interstices of the teeth. More rarely we have observed the sporanges of the *Mucor mucedo*, some of the lower fungi, such as the *Phycomycetes nitens* and even minute nematode worms, such as the small vinegar mite, as well as such organic débris as fibers of cloth, grains of starch, and bits of hair, fur, etc. Photomicrographic views of these pathological germs and these heterogeneous mixtures offer many surprises to persons who have been harboring them in their habitations.



A FRENCH BILL ACTUALLY FOUND IN CIRCULATION BY THE INVESTIGATOR OF DIRTY MONEY

The differences in the bacteria found on bank notes and on coins are not so great as might be supposed. All of the microscopic algæ, in fact, pullulate much more freely upon the

CONTRARY TO GENERAL IMPRESSION, COINS MAY BE NO LESS FILTHY THAN BILLS

REMOVING THE BACTERIAL INCRUSTATIONS FROM COINS FOR MICROSCOPIC EXAMINATION

latter than upon the former; on the other hand, there are many more colonies of microbes to be found upon the grease spots and within the black and tortuous folds of the paper money.

Samples taken from the surface of metal coins are examined in the same manner as those taken from paper money. The incrustations of dirt in the crevices of the coins are scratched and the particles obtained put in a drop of distilled water and placed upon the object glass of a microscope.

Dr. William H. Parker of the United States has recently made a number of interesting studies along this line. He began by sowing bank notes and coins with the bacilli of diphtheria; upon later examination he found that these germs retained their virulence for several weeks. He then subjected to microscopic analysis the daily money receipts of various business houses. In this manner he discovered no less than 26 diphtheria baccili colonized on copper pennies; forty upon silver half dollars; 1,250 on comparatively clean bank notes and colonies containing as many as 75,000 living on dirty bills. Dr. Thomas Darlington, Director of the Bureau of Health in New York, has made the proposition that "greenbacks" should be withdrawn from circulation, because of the deplorable habit of most persons of handling and folding them so that they can be slipped readily into their pockets. After a few months of such usage these rolls of American paper money are scarcely safer to handle than our infected small French notes!

An American technologist named F. B. Churchill has invented a means of "rejuvenating" \$5, \$10 and \$20 bank notes no less than three times before it becomes necessary to destroy them. This method consists in washing and drying the notes in the following manner: They are first placed in a hollow ball having its surface pierced with a number of holes; the ball is then put into a boiler within which a very hot soap and water solution is circulating with great rapidity. After this preliminary cleansing the ball (this huge spherical colander) is removed to a vat full of a "solution" of starch, and then into a third container where the contents are dried by a current of air. Finally, the notes, which are now both clean and dry, are "ironed" by being passed through hot metal rollers.

Still more recently an improved machine has been invented by Mr. I. Ralph, the Director of the United States Treasury at Washington, which is capable of washing and disinfecting dirty bank notes at one and the same time. The soiled notes

ANOTHER EXHIBIT OF THE DANGERS TO WHICH THE HANDLING OF COINS AND BILLS EXPOSES ONE

are placed between two endless bands of cloth and are thus carried first through the wash-water and then through the rinse-water. They are then submitted to gentle friction or rubbing while at the same time the cleansing process is continued by the alternate saturation with a disinfectant and "squeezing dry" of the endless bands of cloth. Before leaving the apparatus they are passed into a second pair of cloth bands which run through large iron rollers heated by gas; these rollers dry them and smooth them in a single operation. With this machine a couple of women can wash 4,000 bills per hour, not only destroying all microbes, but disinfecting them so as to make them sanitary and fit to be delivered once more to the public.

When bank notes are too much worn, too dirty, or too badly mutilated to be fit for public circulation they are destroyed either by chemical processes or by fire. In the United States bundles of condemned bank notes are thrown into huge cutting machines whose immense blades quickly reduce them to fragments. The latter are then macerated in a solution of caustic soda or potash till they have been transformed to a pulpy liquid. In France, however, this mode of treatment was long ago abandoned and the notes are incinerated instead.

The apparatus used for this purpose in the National Bank of France is heated by a gas furnace. It is composed of a simple metal retort having a false bottom, and provided with openings at the top and bottom which can be closed by tampons; it is almost entirely surrounded by a jacket of fire-brick. Thanks to certain clever devices connected with the apparatus the heating of this ingenious crematory furnace is very largely accomplished by the distillation products which proceed from it. For this reason 50 fr. worth of gas is sufficient to reduce to ashes 15 million hundred franc notes!

It is certainly greatly to be hoped that the various Chambers of Commerce in authority will give the order that the bills and notes issued during the war which are now in such a lamentable state be withdrawn from circulation and committed to the flames. It is to be hoped too that these filthy rags which are such dangerous agents of infection will be replaced as soon as possible by 1 fr. and 2 fr. coins of aluminum bronze. It may be remarked here that *Schizomycetes* is the term preferred by botanists to designate the minute vegetable organisms more popularly known by the name of bacteria. They consist of single cells, which may be round, oblong or rod-like in shape, or of aggregates of cells. They lack the chlorophyll or green coloring matter possessed by plants higher in the scale. They multiply with enormous rapidity by the process of cell-division. It is because of the absence of chlorophyll, that marvelous chemical substances which enables plants with green leaves to elaborate organic from inorganic substances, that nearly all bacteria are either parasites or saprophytes, *i.e.*, they prey upon either living matter or dead.

The usual size of bacteria is 1 micro-millimeter in diameter and from 2 to 5 times as long, though both smaller ones and larger ones are known. Some bacteria produce spores—these are minute reproductive bodies which represent a resting stage of the organism. When "ripe" these spores are spherical, ovoid, or long-ovoid in shape. They are extremely small—*e.g.*, those of the *Bacillus subtilis* measure only 0.0012 mm. in length by 0.0006 mm. in breadth. Spores are doubly dangerous as agents of disease, first because of their minute size, which enables a single dirty bill to harbor many thousands, and secondly, because they are extremely resistant to destructive agents such as heat, cold, dryness, etc. They are capable on the one hand of germinating immediately under the proper conditions of food and moisture, and on the other of retaining their vitality for months or even years.

In closing this brief article the writer wishes to lay especial emphasis upon the truly filthy and disgusting practice to which many persons are addicted of facilitating the counting rolls of bills by moistening the finger in the mouth—thus affording any pathogenic germs an immediate entry into the body. Other careless persons run a risk of deadly infection by holding a bill between the lips when making change, and still others by handling dirty money and their bread or fruit without first washing the hands.

Migratory Cells*

Recent Studies of the Part Played by Cells that Wander from One Tissue to Another

By Jean Dufrenoy

RECENT researches in zoology and botany have given us fresh information and new examples of migratory cells, which are capable of changing their position in the inert milieu between the cells of the tissue or even of penetrating other cells.

The former, which are true migratory cells, change the position of their complete cellular bodies from one region of the organism to which they belong to another, or even quit the original organism in order to emigrate into some new host.

Other cells remain immovable, as respects their original structure, but they prolong themselves in such a manner as to extend into the tissues which surround them.

I. INTER-CELLULAR MIGRATORY CELLS

Among molluscs there may be observed a transition from total migration to localized migration—in other words certain outer or ectodermic cells migrate entirely toward the mesodermis losing all connection with the ectodermis which produced them, while others merely extend their sole proximal extremity, prolonging it into the mesodermis, while their distal portion remains in its original position in the ectodermis.

a.—HYPHAL CELLS

The processes or prolongations of a cell extending into neighboring tissues are sometimes excessively elongated, forming in the Laminaria (certain seaweeds) what Sauvageau has termed "solenocysts" and "cylindrocysts" and in certain of the Phanerogams or flower-bearing plants laticiferous or latex-containing cells, latex being the milky fluid found in many plants, one of the best known examples being rubber.

These hyphal cells travel between their kindred cells by digesting the pectic lamella which cements the membranes, behaving exactly like those endothophic or internal parasites which occasion no reaction on the part of the organism which acts as their host.

b.—THE TRUE MIGRATORY CELLS

The mesenchyma produces cells which wander from one tissue to another either perpetually or temporarily. (For the benefit of the lay reader it may be remarked that the mesenchyma is the term given in embryology to the network of branching cells from which are produced the connective tissue, the blood, the lymphatics, etc., etc.).

*Translated for the *Scientific American Monthly* from the *Revue Générale des Sciences* (Paris) for November 30, 1920. The original article contains no less than fifty notes referring to the various authorities consulted in its preparation. Because of our limited space we are obliged to omit these except for a few which we have incorporated in the text.

The former of these, which are known as amoebocytes and which have been the object of much research, may be produced in great numbers by the mesodermis in general or by certain of its differentiated areas. Their production is regulated by the conditions of metabolism in the organism at any given time; thus it is greatly increased, even to an exaggerated degree by certain infections, whether these be accidental or experimental (Vide Chapter 3).

Their migratory activity is variable and depends upon what is known as "functional gymnastics"; this activity can be much augmented by vaccination.

The various tissues are more or less easily penetrated by the migratory cells or amoebocytes—some tissues allow these cells to circulate freely in their midst, others derive food from them or imprison them, as in the case of the plasmatocysts.

The degree of penetrability to amoebocytes also varies with the physiological condition; *e.g.*, the gangrene of Wrisberk becomes infiltrated with lymphocytes in subjects suffering from syphilis.

In the course of ontogeny (*i.e.*, the development of the individual) while the organs are being formed by the grouping together of typical migratory cells, there sometimes occurs a rearrangement in the distribution of the cellular materials which may profoundly modify the original organic relations. Thus there may be *an inversion of the lamellæ* or *the body may be rendered dissymmetrical.*

1. *The Inversion of the Lamellæ.*—Among various larvæ as well as among many seedlings the superficial cells may become buried in the interior of the body.

Thus, the ectodermic and endodermic lobes are inverted in the sponges, when all of the ciliated superficial cells are buried in the interior of the larva to form the endodermis.

This inversion takes place at an earlier stage in the *Microcyema vespa* in which the fifth uneven cell—the most external cell of the embryo—insinuates itself among the four other cells and becomes completely internal.

Instead of being complete, however, this inversion may be *reduced to a mere tendency*—thus certain ectodermic cells bury themselves in the mesodermis in order to form the spicules of the stony framework or skeleton of the coral, or to form the oenocytes of the adipose masses of the ant.

It is by means of an inversion, also, that the so-called "muticlavre cells" are formed in the laminaria (*Sacchorhiza bulbosa*); these quit the cortical ectodermis and become buried in the interior of the thallus where they unite with the original elements of the pith leaving the other cells the function of filling the hollow spaces.

2. *The Cellular Rotations.*—It is possible in some cases for the larval development to cause an alteration in the organic relations, whereupon certain cells may undergo a change of position. Lameere has explained the dissymmetry found in the nematogen (the vermiform embryo) of the Dicyemids as being due to a rotation through 90 degrees of the internal mass, thus setting in a row three couples of internal cells originally having a transverse arrangement.

However, examples of torsion due to an *active movement* of cells are quite rare, since the "rotation" of cellular masses may be *merely a relative phenomenon,* as shown by Van Wijhe in his explanation of the asymmetry of the larva of the *Amphioxus lanceolatus.* Thus, the researches made by Boutan, supported by an analysis of the observations of previous investigators, enabled him to explain as being *due to a simple inequality of growth* all the successive causes of the dissymmetry found in the gastropods—*i.e.*, the rotation of the anal region and of the spiral twist of the shell around the longitudinal axis of the embryo (a rotation limited to the region of the abdominal organs in most of the opistobranches—a division of the gastropods), but extending to the average visceral area in the prosobranches (*i.e.*, having the gill anterior to the heart), the torsion upon itself of the œsophagus and of the nervous system; the secondary involution of the shell; and even the possible phenomena of external regularization; or, finally, the displacement of the definite marks of the shell in certain of the lamellibranches (triacne, etc.).

c.—The Roll of the Amoebocytes

Amoeboism represents the simplest method of the capture of food—a mode which is unique in the amoeba or in the metazoan animal (the metazoa include all animals higher in the scale than protozoa) having no digestive gland, a temporary method in many ovules (*hydra*, etc.), and an accessory method in all of the metazoa which possess phagocytes; the bedbugs even specialize in their amoebocytes, employing them for the purpose of digesting the excess sperm not utilized in fecundation.

It is the office of the amoebocytes to carry nutritious or residuary substances and distribute them and to gather them and eliminate them. Thus it is their function to carry to the new points of calcification in the *Pluteus* (a free-swimming larva) the lime borrowed from the original spicules and to construct the spicules found in the sponges, the corals, the tubitores, and the alcyonaria.

The Bryozoa (or moss animals), the Echinoderms (starfishes, holothurians, etc.), and the Oligochaeta (including earth worms and fresh water worms), actually possess collections of excretory amoebcytes which may be considered to amount in practise to a dissociated organ of excretion, as pointed out by Durham in 1891, in his article entitled *Wandering Cells in Echinoderms* in the quarterly journal of the Microscopical Society.

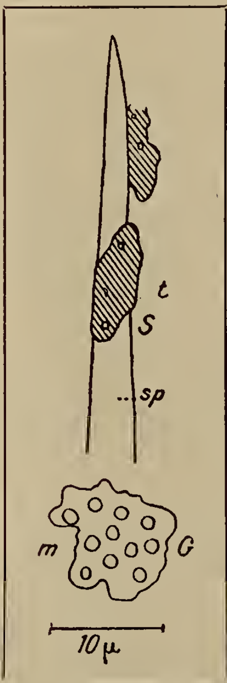


FIG. 1

Actinoblasts of a calcareous sponge which has been for some time in a solution of toluidine blue. *t*, diffused color; *sp*, calcareous spicule; G, granulated amoebocytes, showing inclusions

Affinity Between Amoebocytes and Chemical Salts. — Amoebocytes undoubtedly owe their specific properties to their affinity for various salts. In the transparent animals (*Salpa*, *Hyperia*, big head fish, etc.), when they are examined in a living condition after being placed in solutions of aniline colors we may observe amoebocytes choosing their colors, so to speak, *i.e.*, becoming electively tinged in the midst of organs which remain uncolored. Again, in the case of sponges (*Leucosolenia*), etc., which have lived in solutions of methyl blue or toluidine blues, the actinoblasts (Fig. 1) and the Granular amoebocytes (Figs. 2 and 3) exhibit colored inclusions. Finally, the rapid coloration of the "figured elements" of the blood in animals which have undergone injection is a well-known fact.

d.—The Destiny of Migratory Cells

Large numbers of aboebocytes are arrested in the conjunction tissue which they serve to enrich, being found especially in the zones which are differentiated in the lymphoid organs—in the thymus there may be observed an epithelial framework enriched with mesodermic amoebocytes.

Sometimes the migratory cells acquire a very high degree of specialization; for example, among the *Cnidaria* (thread cells or stringing cells) many migratory cells during their long travels from their point of origin become differentiated into Nematocysts. Still other amoebocytes group themselves so as to form frameworks of autonomous organs, especially of sex organs: the future germinative cells, which are originally free and migratory in the sponges, the Coelenterates, the Ascidians, etc., and the vertebrates betake themselves to their definite location both by means of their own migration as well

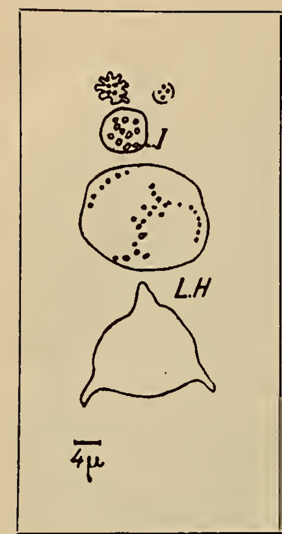


FIG. 2

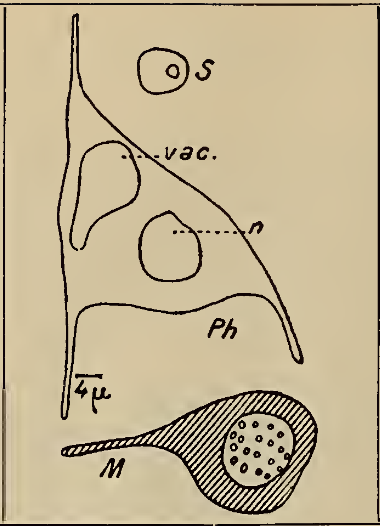


FIG. 3

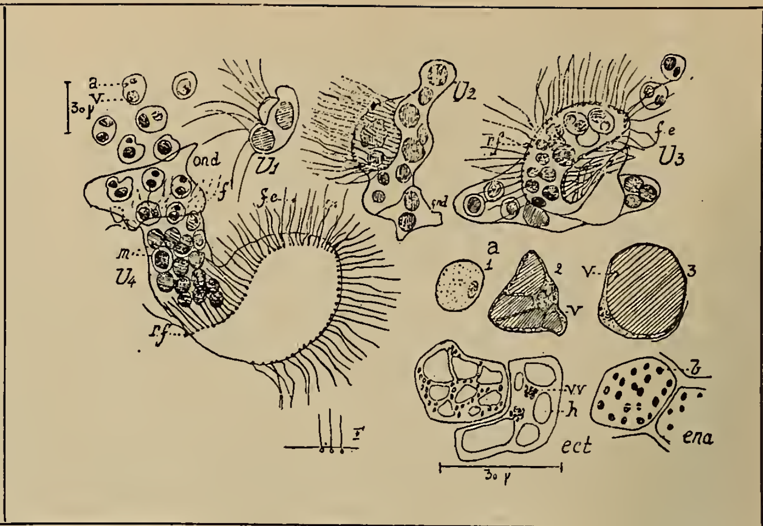


FIG. 4

Fig. 2: Living amoebocytes observed in a living hyperia after having been immersed for fifteen minutes in a solution of toluidine blue. *l*: cyanophile inclusions. Fig. 3: Ph., Phagocyte of the larva of the stemographic bostricha ready to enter the nymph stage. M. Basophilous ctyoplasm. *vac*, vacule. *n*, nucleus. *s*, young cell with sperms. Fig. 4: Agglutination of the amoebocytes in a living Molgula ampuloides colored by toluidine blue. *a*, amoebocytes; *v*, violet-colored vacuoles; U_1, U_2, U_3, U_4, cilated urns of the coeloma, agglomerating the worn-out amoebocytes

as through local inequalities in the growth of the embryo.

When the sex cells have ceased to be amoeboid in character they are capable of annexing to themselves the amoebocytes which transport them, protect them and nourish them, either as they are or by constructing organs specially adapted for that purpose. The most beautiful example of this process is found in the Medusa; this creature has its origin in the Gymnoblastid Hydras (*Cordylophora*, *Pruvotella*, etc.) in a medusary nodule formed by the grouping around the genital masses of amoebocytes which have emigrated from the ectodome of the gonophore.

Whether it be determined by the sex cells or by endo-parasites this attraction appears to be specific in character; parasites such as the Urostora, the worms and the Entomophages are not surrounded unless they are either dead, encysted, or have been introduced into the bodily economy in the form of eggs.

In the mussel those cells which surround the diatoms in a pearl are not migratory but proceed from an invagination of the ectoderm of the mantle, as described by L. Boutan, in his article entitled "The Real Origin of Fine Pearls" (*Arch. Zool. Exp.*, p. 75, 1904).

However, an accumulation of amoebocytes at any infected point of the organism *may be occasioned* by endotrophic bacteria or fungi.

SUMMARY

To sum the matter up. many migratory cells appear to be destined to undergo a speedy death by degeneration of a fatty, a pigmentary, or a sclerous nature. Becoming choked with waste products they become agglutinated as shown in Fig. 4. and either accumulate at certain points in the organism or else are eliminated from the latter. The pigmentary cells accumulate in the liver (*Ichtyopsides*) and the skin, while the scleroblasts accumulate in the skeleton.

There are some other amoebocytes remaining indefinitely youthful and which are even capable of *avoiding death by means of intra-cellular migrations*: thus the migratory gonocytes of the Dicyemids are preserved by the ectodermic cells which harbor them, while the sex cells deintoxicate themselves by conjugation. But this quasi-immortality which the indefinite repetition of the process of sex union confers upon germinative cells, may become absolute in those cells which become cancerous, while, at the same time, they acquire the power of migration.

II. THE INTRA-CELLULAR MIGRATORY CELLS

Among its other properties the migratory cell retains that power of the phagocyte which enables it not only to change its position in an inert medium but to penetrate living cells.

There is no qualitative difference—but merely a single quantitative difference due to the respective size—between the migratory cell which penetrates a cell bigger than itself and the larger cell which "swallows" or surrounds a smaller one.

The cells which thus penetrate each other may be sister cells or kindred cells, and may belong to the same individual or to a different individual of the same species, or even, in many cases, to different genera. The destiny of one or another does not depend upon the degree of specific relationship between the plasmas in question, and neither is it always and inevitably the larger cell which devours the smaller one. We may have no less than eight different cases according to the circumstances involved:

1. A simple inclusion; thus in the infusorigenia of the Dicyemids the first spermatogonium immediately penetrates its sister cell which becomes a follicle (*Lameere*).
2. Endo-parasitism.
3. Phagocytosis.
4. Plasmogonia without caryogamy (provisory or definitive *Sponge*, and Prenant: *The Giant Cells* in *Re. Gen. de Sci.*, p. *Sponge, and Prenant*: *The Giant Cells* in *Re. Gen. de Sci.*, p. 370, 1910, etc., etc.).
5. Plasmogamy characterized by deferred nuclear fusion (the formation of di-karyons).
6. Adoption of the nucleus of one cell by the other.
7. Auto-mixia (union of nuclei proceeding from the same nuclear division, or else of sister cells or of kindred cells).
8. The conjugation of cytoplasm with cytoplasm and of nucleus with nucleus.

Endo-parasitism is in no way connected with a specific difference of plasmas—it may be observed between sister cells in the sporogonias of the *Narcomedusae* of the genus *Cunina*, and also in the axial cell of the nematogene of the *Dicyemids*. In this case a cell divides into two cells of unequal size, and the smaller of the two new cells then penetrates the larger one—the future axial cell—and there develops independently, becoming a mother cell giving birth to gonocytes.

Some of the gonocytes emigrate from the mother cell, and then from the axial cell, in order to immigrate into some peripheral cell of the larval ectoderm, wherein their nucleus is *adopted without either laryogamy or plasmogony*.

An immigrant cell, after undergoing a temporary fusion

with the cell which it has penetrated may resume its individual character, and there exist between phagocytosis and syncitial fusion all the intermediate stages, illustrated by the "polynucleated masses" of the larvæ of silicious sponges and by the syncitium of Van Beneden in the placentary villosities.

Apropos of the former, Delage has brought to our attention that stage of the larvæ of the *Incalcaria* in which all the subepidermic elements send forth pseudopods and form a network, either retaining their individuality as in *Esperella* or else losing it temporarily in the course of a demi-phagocytosis which follows upon the liberation of the ectodermic cells.

III. THE ORIGIN OF MIGRATORY CELLS

Life consists essentially of motion—its *simplest biological expression is the amoeboid cell.*

Cellular migration must have had its origin in an inequality of growth in the first living cell, whose mass increased more rapidly in the region of the space most favorable to nutrition.

But, between the cell which increases unequally in the different dimensions of space, by means of prolongations extending from a fixed initial mass, and the cell which drags along its entire cytological by means of its pseudopods, every sort of intermediate condition is to be found.

Like rapidity of growth, rapidity of migration obeys the law established by van 't Hoff for the velocity of reactions and doubles with a rise of 10 deg. Cent. in temperature. The power of migrating—*acquired originally* and basically *through inequality of growth*—has been *lost secondarily through specialization*: first, because of their grouping to form tissues, in which certain cells alone remain migratory in order to provide for the needs of the others which have become fixed, and secondly because of the acquisition of cilia, which enable the cell to dispense with movement in the surrounding medium by means of their powers of causing motion in the medium itself.

As a matter of fact *amoeboism remains an essential characteristic of every cell;* while remaining merely potential so long as it is masked by histological specialization, it exhibits itself in the less highly differentiated cells, in the sex cells especially, which, along with their other vital manifestations, faithfully retain their power of migration.

It is amoebocytes which produce, by means of lymphocytosis, karyokinetosis, or other similar reactions, the activity of Metazoan animals which are super-excited by means of toxins (Vide, "The Production of Leucocytes in Cultures in Vitro in Fragments of Spleen," *Rev. Gén. d. Sc.*, p. 3, Jan. 15, 1920).

When cultivated outside the organism, not only the hematopoietic tissues, but even such highly specialized tissues as muscular fibers, produce amoeboid cells by means of a return to the original type, by metaphanic variation.

When the cells of frogs' eggs are introduced into the peritoneal cavity of a frog they do not become differentiated, but yield cells of an indefinitely embryonic or sarcomatous character, each of which is capable of individual migration into the tissues of the host.

In the same manner the cell which becomes cancerous acquires that property of the migratory cell which enables it to insinuate itself irresistibly into the adjacent tissues there to form the cords of a tumor, and this is the case not only in animals but even in plants as shown in Figs. 5 and 6 (Vide E. F. Smith's "Studies in the Crown-Gall of Plants and Mechanism of Tumor-Growth in Crown-Gall," in *Journal of Cancer Research*, Vol. 1, No. 2, April, 1916, and in *J. Agr. Research*, Vol. 8, No. 5, 1917).

CONCLUSIONS

The amoebocyte, the simple form of the isolated cell, a temporary phase found in many cells which later become fixed and specialized, a state which always persists in some cells at least of all the higher animals—a state of equilibrium toward which there is a tendency in every cell which is produced under the influence of differentiating abnormal factors,

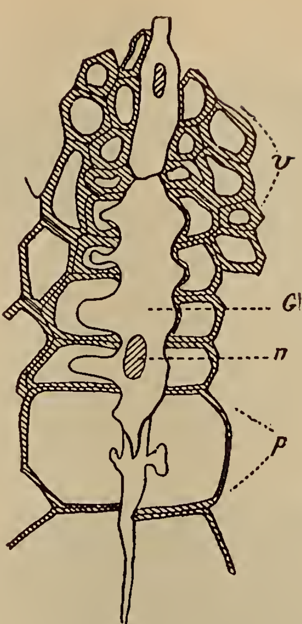


FIG. 5

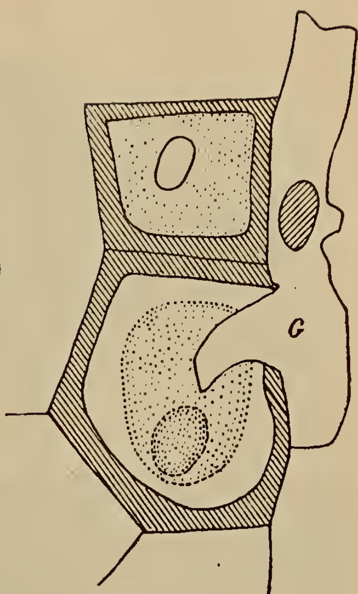


FIG. 6

Fig. 5: Cancerous cell in an experimental tumor produced in the Sylvestre pine tree. The concerous cell, G, has issued from the cambial neoplasia, inserting itself between two rows of cells, which it spilts like a wedge, while the lateral walls form a hernia in the separated cells. *n*, nucleus; *p*, new spring growth of wood; *v*, autumn wood. Fig. 6: The penetration of a migratory cancerous cell (G) within an adjacent cell whose cytoplasm undergoes plasmolysis

appears to exhibit merely the *faithful image of what the original* cell was, starting from which functional specialization has molded all the others in the form of a continuous series.

THE RELATION BETWEEN GROWTH AND SAP CONCENTRATION

In summary of experiments made to determine the relation between growth and sap concentration, Prof. Howard S. Reed of the University of California says in an article in the *Journal of Agricultural Research* for April, 1921:

(1) Observations on the growth and sap concentration of young trees showed that the two variables have a tendency to vary in opposite direction—that is to say, rapid growth is associated with a generally lower concentration of sap in that shoot.

(2) There was a gradual increase in sap concentration as the season advanced. In apricot trees the concentration continued to increase for some time after active growth had ceased. The accumulation of solutes in the plant sap is unquestionably related to the synthetic metabolism of the tree as the season advanced, though there is some evidence that diminished water absorption was partially responsible for the increased sap concentration.

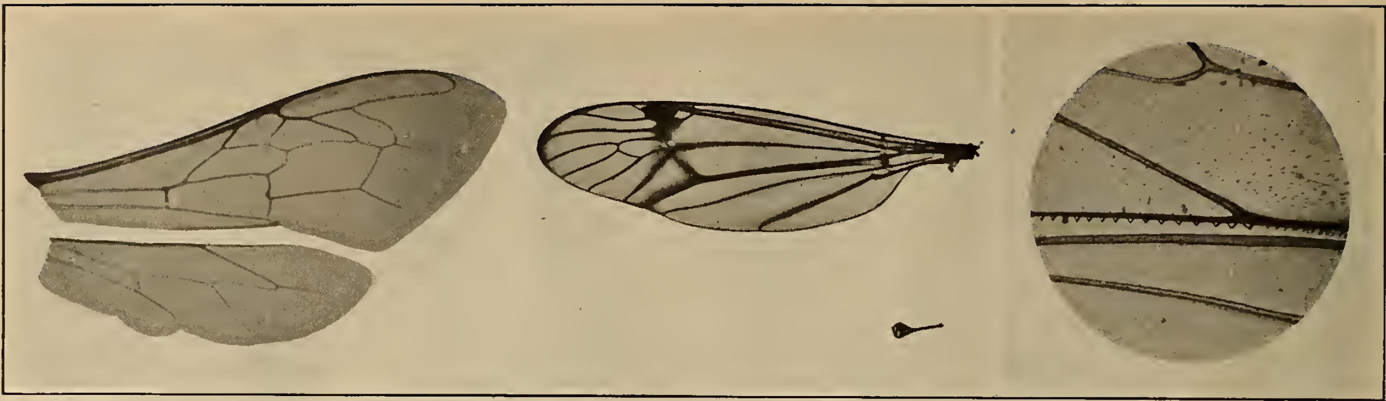
(3) Of several environmental factors measured, soil moisture was the only one having an obvious effect upon sap concentration. The addition of water to the soil usually diminished the concentration of the plant sap.

(4) The sap concentration of shoots on trees heavily pruned was lower than that of shoots on trees not pruned.

(5) A concentration gradient appears to exist in the shoot. The concentration of the sap in the apical portion of a stem was greater than that in the basal region.

(6) Lower concentrations of plant sap in the shoot as a whole appear to be associated with abundant intake and rapid vegetative growth. Higher concentrations are associated with slow growth and fruit-bud formation.

(7) The results seem to indicate that the practice of summer pruning fruit trees is not only necessary but may be detrimental.



DETAILS OF THE FLYING MECHANISM OF CERTAIN INSECTS, MAGNIFIED AS INDICATED

Left: Wings of the bee (x5). *Center*: Wings of Pachyrhina creata (x2). *Right*: In the bee, the hooks on the forewing catch on the hindwing (x30)

How Insects Fly

The Mechanism of Flight of Various Species Contrasted With That of the Birds

By E. Bade

IN the light blue haze far above the dust of the earth an eagle is slowly circling. He is nothing more than a tiny spot; the wings seem motionless when seen through the most powerful glass. He seems to float in the ether as if in an unbound ocean, carried, lifted, and pushed forward by the light atmosphere. But here flight is only made possible by the active motion of the planes. They beat upon the air and so produce a conscious lifting effect which is larger than the weight of the animal's body. Most birds produce a forward motion when moving their wings, for the wing of the bird is movable along its front length, and the posterior part gives to the atmospheric pressure. The wing, like the propeller of an airplane, pulls the body forward through the air.

The wings of the insects are built upon an entirely different principle than those of the birds. Here it is not a development of an extremity analogous to the arms of man, but it is a membranous fold of the thorax and appears, in the pupa stage, as a new formation. It has been believed that the wings of the insects originated from bushy tracheæ which were protruding from the body into the water and utilized as breathing organs. Even today a few lower forms of insects are found which possess tracheæ protruding into the water. In form they are small, wing-like, leaf-shaped appendages of the body, and observations have shown that practically full developed insects in the order of the Neuroptera use their wings for swimming around in the water. The water-inhabiting *Hymenoptera* (certain wasps) *Polynema natans*, and *Prestwichia natans* use their wings, even in a fully developed state, for the purpose of swimming about in the water.

But this theory is by no means satisfactory for it demands that all winged insects must have originated from water-inhabiting larvæ. When the order of the *Ephmerida* (May-flies) are studied in detail, it is seen that the tracheal gills are embryologically abdominal legs and therefore the thorax should have equivalent tracheal gills besides having the legs. If the new theory is to stand, the origin of winged insects, in all probability, can be found in jumping insects. Here the wings originated as an independent broadening and lengthening of the thorax—the meso- and metathorax—which later became an independent appendage. At the beginning of their development these could only act like a glider and so were able to lengthen the natural jump of these animals.

Nearly all of the insects existing today have developed from forms having two pairs of nearly equal wings, moved independently from each other, and each pair having an equal share in propulsion. This form of the wing is still found in the two orders represented by the darning needles and the dobson flies.

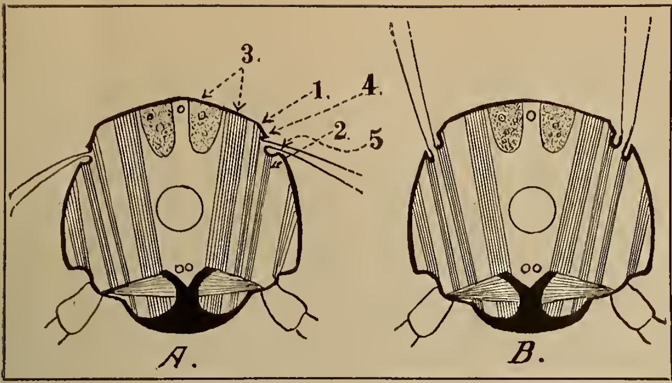
The wings of the insects developed as an elongation of the thorax; and into the more or less dome-shaped protuberance from which the wings arise, tracheæ have grown. The wings, like the rest of the exoskeleton of the insect, consist of an inner layer of living cells and an outer chitin. When the wings are fully developed the inner cells dry up and disappear leaving the outer layer as a fine thin chitinous membrane. The dome-shaped protuberance found in the undeveloped insects quickly grows in length, little in width, and not in thickness, so that it forms a much flattened sack which gradually develops into the wing.

The fully developed wing therefore consists of two very thin and connected membranes between which lie the now chitinous tracheal tubes which brace the wings and give them the desired stability necessary for flight. Such an insect wing is a master work of nature, it has great strength combined with but little weight.

When considering the flight of birds in the final analysis, it is found to be essentially a gliding motion, while the flight of the insects has a tendency to rise straight upward. For this purpose the bodily size of far the greater number is small, making a violent beating of the wings a necessity. The number of wing beats per second varies with the different species: darning needles have 28 per second, the bumble bee 220 per second, the bee 330 to 440, and the house fly 400 to 600 per second. These figures are extraordinarily high, and they are more illuminating when compared with a propeller of a flying machine which only averages about 25 revolutions per second.

The aerial dance of the mosquitoes as they rise and fall above the mirror of the pond shows this lifting or rising power very distinctly, and the rapid vibration of the air set in motion by their flight is heard as a buzzing sound.

The bird's power of flight is the direct result of muscle power, but the flight of the insects is not a result of the pressure of muscles. Here the wing roots are found at the base of the wings at the edge of the thorax and the wing receives its motion by thoracic levers which are attached to the root of the wings. When both the ventral and dorsal levers of the thorax meet each other, the wings are forced upward. This is accomplished through vertical bundles of muscles stretched between dorsal and ventral thoracic segments. Pressure at right angles, the horizontal, is exerted at



MODEL CROSS-SECTION THROUGH THORAX OF A TYPICAL INSECT

A: The extreme downward stroke, and *B*: The extreme upward stroke, of the wing. The lifting muscle, 1, and the downward-pulling muscle 2, are attached to the levers 4 and 5. The muscles indirectly used in flight are designated by 3.

the downward beat. At the same time they press a chitinous rod below the base of the wings, lift it upward, and, at the other end of the lever, the wing is carried downward. On every beat of the wings, the levers of both the ventral and dorsal side of the thorax are pressed together and forced apart again. To this motion is to be added the curvature which the wing describes. This is accomplished by tiny chitinous pieces found at the base of the wing which produce leverages more or less complicated in detail.

The flight of the birds is alive. Muscles, nerves, and blood vessels have their place in the scheme of things, the entire structure is under the direct influence of the will. The motions of the insect's wing is accomplished with a number of chitinous levers, one pressure in a certain direction loosens an enormous number of complicated motions. Here the entire wing is a dead formation, while the wing of the bird is built up of living cells.

The best form of wings for direct upward flight are those flat wing expanses found in the insects; curved wing surfaces are best adapted for gliding. But the insects have not enough strength for such a gliding flight, they cannot keep themselves at a constant level for any length of time. The body lies back of a point of equilibrium where all the air resistance is found and therefore these animals cannot perform a gliding flight. The birds can glide, the two wings form one surface with the body, which is not the case with most of the insects, for here the wings are attached to the body at a point. The wing can produce curves in the air without hindrance, which in the wing of the bird, is impossible. This twisting motion of the wing practically reduces the air resistance to the zero point. to this, the air above the wing is rarified which also helps to lift the body.

In flight the butterflies place the posterior edge of the forewings upon the anterior edge of the hindwings. In some of the butterfly families the wings are more closely joined together. Here a strong, springy elongation, the jugum, projects backward from the base of the forewing. This lobelike process holds the front- and hindwings closely together and also makes it possible to spread them very rapidly. In flight both wings on the same side are beaten up and down in unison. The true butterflies, or day butterflies, beat their wings very slowly while the moths, on the contrary, beat their wings with great rapidity. When the butterfly shortens the wing surface on one side by drawing one wing over the other, or by some other means, its more or less gliding flight is changed into a curving flight. Here gravity and pressure lie close together making it possible to glide toward any desired

NOTONECTA UNDULATA, THE COMMON WATER-BOATMAN OF THE UNITED STATES, MAGNIFIED 2½ TIMES

AGRION SPEC., ONE OF THE DAMSEL FLIES

The upward beat of the wing throws the air upward and backward, pushes the air to the rear, and drives the insect forward. This is especially emphasized by the moths which are known as the best fliers of the insect world. The downward beat of the wing lifts the body upward, but in addition object such as a flower, etc.

In some insects, especially the grasshoppers, the forewings are seldom used for actual propulsion when in flight. The same is true of some of the beetles. Here the forewings have become changed by the passing of time, into thick, leathery or chitinous, hard wingcovers which protect the delicate membranous hindwings when at rest. When in flight the greater part of the beetles keep their wingcovers expanded, horizontal, and motionless with the anterior margin slightly higher than the posterior margin. These act as passive wings in the flight of these insects. It has been noticed that the June bug uses its hard wingcovers actively in flight and that they help to lift the beetle upward while the membranous wings drive the insect forward. The gold shimmering rose beetle, *Cetonia*, only lift their wingcovers to let the membranous wings come forth. They are pushed sideways from under

the covers and fly with extroardinary agility, turning and circling about the flowering shrubs.

The large fore- and the small hindwings of the bees are more closely united in flight. Here a row of tiny hooks is found on the front margin near the center of the smaller hind-wing. These hook into the downward-bent back margin or depression of the posterior margin of the frontwing.

The hindwings of the flies have developed into balancers which resemble a bristle terminated by a ball. The large number of wing beats while in flight is dependent upon the small size of the degenerated hindwings. These halteres, as they are also called, seem to play a part in the direction of flight, and some say that they enable the insect to keep its equilibrium and so influence its flight.

Those insects having four wings, and where each one of them has its own independent muscles, move the fore- and hindwings independently from each other. When the hind-wing has completed its downward beat, the forewing just begins it. This is easily observed in the small damsel flies, all species of Agrion in the order of the Odonata, which gives to these insects their peculiar flight. Through modifications in the beat of the wings the damsel flies are able to change the direction of their flight since the muscles are directly attached to the individual wings. The long, narrow abdomen of these insects, in all probability, acts as a rudder thus influencing the direction of flight. Here the point of equilibrium is changed by the abdomen as it moves from side to side. The same is true of the *Hymenoptera* and the *Lepidoptera*. The beetles cannot utilize this method of changing the direction of their flight as their abdomen is rigid. Here the wingcovers come into play and, by a change in their position, the direction of flight can be altered at will.

The bird can shorten its wing in flight on the upward beat by bending the arm bone, this is impossible in the insects. In order to bring the air resistance to as low a figure as possible, its wings must produce curving beats.

The most important work of the insect's wing is to overcome the bodily weight. A special adaptation of the insect's power of flight is the development of tracheal pockets which are similar to the air sacks of the birds, therefore the insects and the birds cannot be likened to a flying machine but rather to a balloon with motive power.

VARIATIONS IN THE HYGROSCOPIC ACTION OF HUMAN HAIR

By A. R. Clawson

It is a well-known fact that hair expands slightly when moistened, and that it resumes its former length when its previous moisture content is restored. This principle is the basis of the German hair hygrometers which are sold in this country and assume to measure accurately percentages of relative atmospheric humidity. But when the hair hygrometer is subjected to a series of tests in comparison with more accurate recorders of relative humidity, it is found to lack many of the essential characteristics of a reliable instrument.

An air-tight cabinet about four feet long was fitted up with a horizontal partition having an opening at either end. Coarse screen was placed over each opening. An electric fan was installed within the cabinet, producing a circulation of air on both sides of the partition and insuring a uniform humidity throughout. Through the roof of the cabinet were inserted wet and dry bulb thermometers of the sling psychrometer type. The hair hygrometers were placed in theupp er compartment as near as possible to the psychrometer. Both single and multiple hair members were tested and hairs of different grades of fineness were substituted. All hair was first treated with ether to remove any oil which would keep out moisture and so prevent hygroscopic action. The humidity tables used were the official U. S. Weather Bureau tables, computed by Professor Marvin of Cornell.

To obtain a given constant high humidity, strips of wet gauze were placed on the screens, the fan started and the cabinet closed until a percentage was reached slightly above that which was required. The fan was then stopped, the cabinet opened narrowly and the gauze quickly withdrawn. After closing the cabinet and allowing the fan to run a few minutes, the readings were taken. For a low humidity, anhydrous calcium chloride and potassium hydroxide were used. In this case the percentage obtained before removing the drying agents was slightly below that required. All readings were taken with the cabinet closed and the fan in motion.

It was found that up to about 60 per cent relative humidity the expansion of hair is quite consistent. Above that point the coefficient of linear expansion becomes slightly less. This difference was difficult to determine accurately, owing to shrinkage of the hair, which set in at between 60 per cent and 70 per cent.

In one typical set of readings, the instruments registered approximately alike up to 60 per cent. At 61 per cent the hair hygrometer registered 59 per cent. At 65 per cent it still registered 59 per cent. At 86 per cent it had risen to 61 per cent. At 88 per cent it had fallen to 55 per cent, at 91 per cent to 53 per cent, whence it continued to fall slowly for some time. The slowing up of the expansion preceding actual shrinkage sometimes began as low as at 54 per cent.

On the day after a high humidity test it was found that the hair member had partially recovered its shrinkage, leaving a discrepancy of from 4 per cent to 10 per cent. The recovery continued in constantly decreasing degree for several days. In repeated high humidity tests two days apart, shrinkage set in at a higher percentage of humidity at each trial, rising from 65 per cent to 90 per cent. Each shrinkage was less than the one preceding. After each moist exposure, the hair lost a part of its hygroscopic properties. In order to obviate any further shrinkage the hair member was subjected to a humidity of 100 per cent for thirty minutes, taken out and thoroughly dried. Upon resuming investigations next morning it was found that it had lost practically all of its hygroscopic properties.

In spite of the exceeding fineness of human hair, it is slow in responding to changes in air humidity. Time is required for the moisture to work its way in or out between the delicate cells and bring the center into the same condition as the exterior. After the humidity has become constant, the hair adjusts itself at the rate of about 1 per cent in ten minutes. No hair hygrometer reading is accurate unless the humidity has been constant for about half an hour. If the percentage of humidity is rising, the reading is too low; if falling, it is too high, the average correction being about 3 per cent. Fewer hairs in the hair member increase the rapidity of action. Finer hair acts more promptly than coarse.

From the foregoing it can be readily seen that any hair hygrometer which is graduated in humidity percentages can be only approximately correct. Hair is at best, a poor recorder of humidity. It seems highly probable that changes of length in human hair correspond to changes in absolute humidity and not relative.

A METHOD FOR ELIMINATING ATMOSPHERIC DISTURBANCES

W. Gerlach (*Jahrb. d. drahtl. Tele.*, Nov., 1920), gives a method essentially consisting in grounding a suitable point of the antenna through a detector of the carborundum or electrolytic type, so that strong atmospherics can go to ground while the relatively weak signals cannot overcome the resistance offered by such a detector. The choice of the point of the antenna is of importance for obtaining good results, as shown by diagrams given in the article. This method has allowed of reception with 4 amplifiers and a Morse apparatus through strong atmospherics, which was impossible with the ordinary antenna. Reproductions of Morse tapes in both cases illustrate the effectiveness of the system.

How Motion Affects Form*

Analogies Between the Behavior of Crystals, Fluids, Lines of Force and Living Organisms

By Karl Przibram

LIKE many other physicists, I have been profoundly impressed during the many years which I have devoted to electrical research by the manifold and remarkable analogies existing between electrical figures and the phenomena connected with extension and morphological outlines in various other realms of nature, particularly that concerned with the flow and "spread" of fluids.

Electrical figures, upon which I hope shortly to publish an extensive treatise, are peculiarly fruitful in such analogies. But different investigators have obtained different results from similar experiments. Thus De Luc concluded from the aspect presented by electrical figures and a comparison of them with the movements exhibited by fluids that electricity flows *in* at the negative pole and *out* at the positive pole, whereas a study of the same phenomena led von Bezold to form an exactly opposite conclusion.

These rather baffling contradictory results appear to me, however, to spring rather from too inadequate than too extensive a generalization of the facts observed.

To begin with we are not concerned with two special kinds of mechanism but with *all* natural processes where extension in space or "spreading" takes place, or at any rate with a very large group of such phenomena so far as *form* is affected by them. It is quite possible that a logical following out of this concept may enable us to form a comprehensive theory embracing all 3 realms of nature in a system to which the term "*General Morphology*" might properly be applied. Certain indications of such a system are already to be found here and there in Nature. We are already familiar with the widespread occurrence in Nature of "*lines of foree figures*," which is by no means confined to the magnetic field and the electric field but can be recognized in an analogous manner in the electric figures and also in the figures made by fluid currents, in diffusion figures and in the division figures of organic cells. Ledus in particular has called attention to this in his *Synthetic Biology* (Paris, 1912), and very generally refers to "*dynamic centers*"; it is he, indeed, who has probably gone farthest in the search for *lines of direetion* having a general morphological significance. The similarity in form of the figures cited is to be ascribed to a similarity between the static or stationary phenomena observed. I should like on my own part to call attention to a connection no less general which exists between *form* and *rapidity of spread* although the basic analogies concerned cannot as yet be reduced to a mathematical formula. Let me begin with a very trivial example. If a drop of ink be placed gently and carefully on a sheet of paper it forms a perfectly round spot, but if on the other hand it be slung forcibly from the point of the pen it spatters and spreads, producing a spot with curved or with jagged edges, or with long tongues extending from it according to the varying circumstances of the case. An increase of velocity is evidently here concerned with the rounded or irregular form of the figure and this can be demonstrated by a whole series of similar phenomena. Closely related to the example just mentioned—figures produced by spattering—are the instantaneous figures of falling drops obtained by Worthington which exhibit the more exaggerated spread made by an increase in the height of the fall which, of course, implies an increase of velocity. Among such examples there also belong the figures obtained by Decharme through the falling of drops or jets of liquid on glass plates upon which red lead has been strewn and which he compares with electrical figures. According to his observations where the liquid falls from a small height concentric rings are chiefly formed, while when the height of the fall is increased jagged figures with radiating projections are formed.

The relationship which exists between form and velocity is exhibited very beautifully in the "*tearing figures*" produced experimentally by R. Arti (*Vide Ark. f. Mat., Astr. o. Fys.* 8, No. 14, pp. 1-11, 1912) and compared by him both to electrical figures and to the dendrites seen in metallography. When a viscous fluid is enclosed between two glass plates and the latter are then suddenly separated, the fluid between them forms dendrites, *i.e.*, branching tree-like figures, and according to Arpi's experiments the greater the rapidity with which the plates are separated the finer the division or branching seen in the figure will be. When the plates of glass are pulled apart slowly the outline of the figures produced by the liquid are straight or but slightly curved. The similarity between these slowly formed outlines, and those of a negative electrical figure is very striking, while that between the outline produced when the plates are rapidly separated is equally remarkable in its similarity to a positive electrical figure.

The present writer came to the conclusion many years ago that the positive electric figures spread out with much greater rapidity than do the negative ones (*Wiener Ber.* 108, pp. 1161-1171, 1899). This belief has received fresh support very recently by the Danish scientist, P. O. Pedersen, who has furnished direct proof of the fact and has succeeded in measuring the velocity of the spread (*Dansk. Vidensk. Selsk. Math. fys. Medd. I*, 11, pp. 1-76, 1919). According to this authority the velocity of spread was from 2 to 4 times as great in the case of the positive figures as in that of the negative ones. Thus, in this instance also it is evident that where the act of spreading takes place more slowly, the form is more rounded in character, as shown in the negative electrical figures, whereas a greater rapidity of spread produces the more branching and radiating form seen in the positive electrical figures.

As we indicated above Arpi has called attention to the similarity of form between various structures exhibiting the dendrite or branching outline, and especially to the crystalline dendrites seen in metals. In such cases likewise, there is a direct relationship between the form of the crystal and the rapidity with which it was produced. It is a well-known fact, indeed, that the formation of crystals of regular form depends upon the slowness with which the crystal is produced, whereas when the growth of the crystal is greatly accelerated (as when the solution is rapidly evaporated or rapidly congealed). the crystal tends to form dendrites or a skeleton outline, such as is shown in the crystallizing dendrite found in cast iron. Thus we see that an increase of velocity is connected in this case also where the matter is complicated by the forces concerned in crystallization with a radiation or stretching and branching of the form finally produced.

The common principle involved in these extremely various mechanical processes concerned in the act of spreading or extension, is probably to be found in the fact that when a spread or extension has taken place in a given direction, an increase of velocity favors an increase of the spread in the said direction.

This holds good for the spread of a sluggish fluid just as it does (because of the peculiar deformation of the electric field) in the case of electrical figures (Vide M. Toepler, *Phys. Zt.*, Vol. 8, pp. 743-748, 1907).

But according to O. Lehmann the formation of the framework of crystals is also to be explained by the fact that as soon as an extension or point has been formed, continued growth at the same point is favored by reason of the alterations

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in the diffusion relations. This tendency to follow an initial path once opened, which leads to the formation of radiated, branching forms, is the more strongly accentuated the greater the velocity with which the extension follows the aforesaid paths, since it is less easy to open up adjacent paths—particularly when there is great resistance offered to the forming of such new paths—and just here there is exhibited a further analogy or coincidence among the examples cited: in the case of electrical figures the greater the electrical tenacity of the medium in which they are produced the stronger their tendency to confine themselves to single branches. Thus in fluids which are poor conductors one is able to obtain only figures composed of a few thin serpentine lines and none of the plane figures such as the negative figures in air. According to Arpi the "tearing apart" figures are increasingly fine in their divisions in proportion to the tenacity of the fluid employed; while O. Lehmann observes that the formation of the framework in crystals is favored by an increase of viscosity in the solvent medium (gelatine).

Still another series of phenomena is probably to be regarded as belonging in this category—namely the figures produced when one liquid spreads out over the surface of another. These have been pretty thoroughly described by Tomlinson (*Phil. Mag.* (4) 22, 249-261, 1861; 23, 186-195, 1862; 27, 425-432, 1864; 28, 354-364, 1864); but since he makes no observations as to the velocity of the spreading action, and since the process was strongly influenced by the presence of various small impurities his results cannot here be employed to support our thesis without further inquiry. It is very doubtful, likewise, whether the relation between form and velocity holds good in the case of the dendrites found in many kinds of rocks by the oozing of water into them, since in such cases the outline of the figure is obviously indicated to some extent by the distribution of the pores in the rock in question. This question might be answered conclusively, however, by means of a series of experiments dealing with the penetration of porous substances by liquids subjected to various degrees of pressure.

Another example, which would appear to contradict the theory we are trying to establish, requires to be mentioned: namely, the well-known fact that when a stone is thrown with a low degree of velocity through a pane of glass the latter is shattered, the aperture produced being surrounded by numerous radiating cracks whereas a bullet makes a smooth round hole; while according to our hypothesis exactly the opposite result should be produced. We regard the system of cracks in the glass as representing the figure due to the spreading prematurely interrupted. In spite of an increase in the tension (velocity) the figures become smaller in this case, since in the resultant discharge of sparks the inducement to a further growth is lessened (complete discharge of the electrode).

An example of a very perfect analogy to the instances cited above is the equally familiar fact that a sheet of asphalt or pitch can be shattered by a sudden blow, whereas on the other hand a ball can be made to penetrate it without shattering it if slow pressure be employed. We may compare with this the observation made by Holtz and by Reitlinger to the effect that the *positive* Lichtenberg dust figure which exhibits the well-known branching radiated form when an electrode which is a good conductor is employed, exhibits an approximation to the non-radiated rounded negative form when a semiconductor (*i.e.*, a wooden rod) is employed instead—that is, when there is a retardation in the flow of electricity.

Considering the very extensive analogy which exists between crystals and living organism it seemed *a priori* not improbable that the connection between form and velocity which we have demonstrated to exist in the former might also be present in the latter. I am indebted to Mr. L. Portheim and Mr. H. Przibran for a proof of this in the following examples which it seems probable might be greatly extended, but which are in themselves quite sufficient to prove the extensive application of the principle in question.

In the investigation of the cases in point, observations and experiments have been made with respect to difference in rapidity of development in individuals of the same or of related kinds. Thus it is a well-known fact that in the case of many sorts of plants the development of the stem is much more rapid in specimens grown in the dark than in those grown in the light. Such '*etiolated*," *i.e.*, pallid and yellowish plants furnish an excellent example of this principle, because the plants which develop under the influence of light show a forced structure with an extensive development of leaf surfaces, while those grown in the dark are generally tall and thin of stalk, while the surface extension of the disturbed foliage is very much less in proportion than the growth in length of the stalk. With respect to this L. Jost makes the following observation: "When we compare an etiolated specimen of *dahlia variabilis* with one which has been grown under the influence of light we find that in the former both the internodes of the stem and also the leaf stalks are inordinately lengthened, while the leaf surfaces, on the other hand, are comparatively small and undeveloped." But according to Wiesner (1891) and Brenner (1900) even in the so-called "rosette plants" such as *sempervivum* (live for ever) the etiolation may consist in a decrease of size in the leaves and in a stretching or lengthening of the otherwise compressed internodes and, therefore, in a disappearance of the leaf rosette. In this case an increase of humidity produces a very similar effect. Many monocotyledonous plants in which the stem is ordinarily more backward in growth than are the leaves, "form in the light as well as in the dark comparatively long sprouts; the leaves, on the other hand, are subject to a marked and excessive increase of length, because of the sustained activity of their basic vegetation point, but remain in general narrower than in the light; therefore, we have in this case also an elongation of the entire form.

In many fungi also the etiolations consists of a marked elongation of the stalk and a corresponding diminution in the "cap" of the mushroom even to such a point that the latter may be entirely missing. An increase of temperature exerts an effect similar to that of darkness, increasing the rapidity of the growth as a general thing up to an optimum point.

A very fine example of the fact that favorable conditions of growth tend to produce more finely divided branch and forms, is afforded by the common fern, *polypodium vulgare*, which appear in two forms: In the normal form the outline of the leaves is lanciolate with simple, deep clefts between the leaflets, while in the second form the leaf is much more finely divided and more abundantly branched. If the latter form is removed to an unprotected location in dry and sterile ground, the coarser normal form again makes its appearance (Goebel). Here, too, the retarding of the growth has resulted in a simplification of form.

In the case of amphibious plants two different kinds of leaves are found upon one and the same individual; those leaves which grow under water are usually much more finely divided than those which grow above water, as in the case, for example, of the *Ranunculus aquatilis*. Unfortunately we lack data in this instance, as to rapidity of growth. Here we have an example in which our assumed morphological principle may indicate whether it is useful upon occasions or whether it must be regarded as showing a considerable narrowing of its dominion. Our assumed principle leads us to expect that the sub-aqueous leaves grow faster than the aerial leaves, but this question must be decided, of course, by actual experiment.

If we turn our attention now to examples among animals we find an analogy to the "warmth etiolation of plants in the case of rats and mice raised in an atmosphere of high temperature (implying a more rapid growth). Under such conditions these animals exhibit a more elongated structure with legs and tails of comparatively greater length; this is analogous to the observed fact that as a general thing races of animals living farther to the south tend to be distinguished by longer extremities.

W. O. Ostwald observed in a species of crab, *Hyalobachina*, a transformation of the broad, short, carapace of the head into a long pointed form by means of an increase of temperature (involving an acceleration of growth). In another kind of crab, *Artemia Salina*, W. J. Schmankewitsch observed an accelerated growth accompanied by an increase in development of the pointed tail lobe and of the terminal and lateral bristle of the tail, in proportion as the degree of concentration of the salt water medium was decreased.

The observation made by C. Paronas that the dorsal appendages of the snail (*Tethys leporina*), which normally have a simple spindle shape, regenerate themselves in a successful case of autotomy in a cleft or branching form is to be connected with the increased rapidity of growth which takes place when a member is regenerated—this being the only case of a formation of multiples due to regeneration, which cannot be attributed to a break and a regrowth of the broken surfaces.

Other instances which may possibly be classified under this principle are as follows: The formation of long horn-like or antler-like excrescences in tropical insects; the frequently grotesque forms of the rapidly growing feathers in the mating plumage of many birds; the fact that stag's antlers with their characteristically branched forms are among the most rapidly growing structure found in the bodies of mammals—in this connection it is worth noting also, that a single true horn which is shed yearly like a year's antler, and is, therefore, obliged to grow rapidly, *i.e.*, that of the pronged-horned goat, is forked.

Observations with respect to the influence of temperature upon the form of the wings of butterflies do not appear, however, to be classifiable under this principle: while a swallow-tail butterfly reared in the cold exhibits, as this principle would indicate, an abbreviation of the tail of the rear wing, it is found, on the other hand, that either heating or cooling causes an elongation of the tails in another butterfly. . . . It is the chief purpose of these lines, however, to indicate the possibility of a more generalized point of view with regard to many questions in morphology, rather than to precisely define the limits within which the present principle is operative.

SUMMARY

There is a definite relation between form and rapidity of expansion in an entire series of phenomena having to do with physical expansion. Such for instance, as the spattering figures and tearing figures made by liquids, electrical figures and the formation of the lattice or framework in crystals. The principle involved is that greater rapidity of formation produces a more extended radiating and branching form, while a smaller degree of velocity corresponds to a more compressed, more rounded and less branching form. This morphological principle appears to hold good, also, in the many phenomena of growth in organic nature, as in the etiolation of plants, the two-leaf forms of the polypodium, "heat rats and mice," differing forms in the hyalodathnia, artenia, and tethys, and stags' antlers, etc.

The Behavior of Crowds*

The Application of Mass Psychology in Explaining Phenomena

HITHERTO the science of psychology has confined itself to the study of individuals. And yet a knowledge of the psychological processes which sway masses of individuals or "crowds" is of great import, not only to psychologists but to sociologists, politicians and even to soldiers. Finally, a technical psychologist, Dr. Walter Moede, has recently demonstrated that the modern method of studying psychology experimentally and statistically can be applied to crowds as well as to individuals. In his new book *Experimentelle Massenpsychologie* (Experimental Mass Psychology) he throws fresh light regarding this matter upon many branches of our social existence, and it is noteworthy that in many cases our ordinary empirical practice is based upon sound psychological principles. The experiments in question made use of Leipzig students and Sorau school children as subjects and were thus, of course, confined to so-called *classified masses* while *chance or haphazard masses or crowds* have thus far not been dealt with experimentally.

The basic concepts upon which mass psychology rests may be briefly stated as follows: Those borders or limits where one individual either begins or ceases to exert an effect upon another, are designated as *collective thresholds*. This effect is most plainly exhibited in the "collective instinct" which is effective in united action. When the person conducting the experiment lifts his arm, the arm of the person subjected to the experiment is twitched in the same direction, as has been proved beyond a doubt by measurements made with the Sommers apparatus. If the arm of the leader is moved downward there follows either a similar motion or an opposite motion on the part of the subject. These experiments find a parallel in the common occurrences of our daily life. In the same class of phenomena are the sympathetic yawning, weeping, and motions of various kinds, which may be observed among the spectators at football games, for example. There is a well-known jest sometimes perpetrated by a practical joker who, by taking a bite out of a sour pickle in the presence of an orchestra of wind instruments can cause all the performers to stop playing through instinctive sympathy, since his action occasions such a strong sympathetic motion that not one of them is able to go on blowing his instrument.

When an *order* is given, the subject or subjects are required to perform some act or make some motion at the same time. The motion made by the person in command is echoed by those under his orders. In the case of the leader of a squad of persons performing gymnastic exercises, for example, the command is really given only in order to regulate the synchronous motion. Acoustic stimuli, such as counting aloud or clapping the hands can also be added, so that a rhythm is produced controlling both the eye and the ear.

The phenomena of expression at once become a bond of united action between living creatures. For our very aspect, our gestures, and even the speech which makes possible intercourse between human beings are based upon the fact that not every smallest alteration of circumstances in the world about us is capable of stimulating us to a reaction, but that on the contrary, the collective threshold must first be crossed.

In every person experimented upon differences are found according to whether he or she is working *alone or with a crowd.* This difference is known as the "*collective valence.*" It has been found that when the same experiment was repeated after a lapse of weeks or of months, that the work done by the same persons improved or deteriorated with respect to the separate work in the same way as formerly within the crowd. The counterpart of the collective threshold is formed by the "collectivistic threshold," the degree in which the *individual sensitiveness* becomes altered when the individual works under collective conditions, *i.e.*, together with another person or with several others.

In order to investigate collectivistic thresholds, Moede required the subjects of the experiment to compare and describe the *intensity of the sounds made by falling balls.* The results of these experiments showed that united action is capable of

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exerting an inhibitory as well as a stimulating effect—in other words that concerted action by a number of persons may be either improved or made worse than that of separate individuals by the mere fact that it is concerted in character. The best observers are disturbed and distracted through being in a crowd, so that the work done by them falls off in quality or quantity, while the work of the poorest observers, on the other hand, improves correspondingly—in short, when all are working together, the work done by each individual tends to approximate that of the others. Since the poor work is in large part due to a lesser exertion of strength the collective working has a favorable effect. But unfortunately, the diminution in the work of the better members of the group overbalances this improvement, so that in this experiment *group working was found, on the whole, to have less favorable results* than that of the separate individuals. The view of theoretic mass psychology, that the crowd is less capable intellectually is thus confirmed by actual experiment.

The sensitiveness to pain was tested by means of an electric current. The presence of the crowd and also the feeling of rivalry experienced by each, with respect to his schoolmates, causes a *diminution in sensibility* to pain, because of the fact that each pupil has an ambition to distinguish himself as a special hero. Evidence of this is found in the experiences of war as well as in those of sport: When in a crowd the pain of individuals is suppressed and often not even felt.

The *will power* of individuals in the crowd was tested by making dots, addition and pressure upon a dynamometer for showing hand-pressure, etc. In this case also the best in the class showed a falling off and the poorest an improvement. In the dot-making test the individual pupils expressed themselves characteristically, but in the crowd they found the work pleasanter than when working alone. The rhythm of the dot-making work, which requires as large a number of dots as possible to be put on a piece of paper within a given length of time, tends to produce unity and uniformity when done in a crowd. Rhythm, indeed, appears to be of great importance in crowd action as shown in the marching step of soldiers, in the rhythm of the sweep of oars by rowers, and in hammering, etc., by a group. Moede tells us that it is possible in the dot-making test to increase the yield of the poorer pupil so that it amounts to double as much as the diminution in yield in the better half of the pupils and this sounds most hopeful.

Some of Moede's tests possess great significance likewise in the domain of the *psychology of labor*. In the united work of tested couples who had been paired with as close an approximation as possible with respect to their abilities, the capacity for work can never be found by mere addition of the individual capacities, as can be done in the case of a machine provided with two motors, and the same thing holds true of the work done by entire groups—namely, their total capacity for work cannot be found by reckoning the sum total of their individual capacities. The consciousness of united action in a crowd, especially when groups are animated by rivalry with regard to each other, inspires each individual to stronger effort. Self-confidence, self-reliance, and self-consciousness all become more intense and each individual feels more certain of himself when acting as a member of the group. On this account *group rewards* may be made effective in industry to *inspire greater effort* on the part of the laborers, provided, of course, the laborers do not *purposely inhibit* their efforts in order not to injure weaker groups.

Of great sociological importance from the psychological point of view is the result just mentioned, because of the fact that it disposes of the objections raised by Simmel against a special mass psychology. Simmel has formulated the following social-psychological problem: What modifications do the psychical processes of an individual undergo when he is acted upon by certain influences through his social environment? Such a statement of the question would make mass psychology superfluous, for this problem is to be solved within the limits of the psychology of the individual. Moede's demonstration that the united action of two or more persons produces larger results than the mere addition of the separate psychical processes and that, therefore, a new unit comes into play, contradicts by experiment Simmel's hypothesis and supports the view of Le Bon and other authorities upon crowd psychology that psychological bonds are created among crowds.

The tests of the power of attention made by Moede also support Le Bon's opinion that the mass or crowd can produce more as regards quantity but remains at a disadvantage compared with individual work as regards quality. The limits embraced by attention were tested by the marking and writing down of figures and the duration of attention by the striking out of certain letters in a given text during a period of five minutes. *Tests of memory* were likewise made. The learning in chorus of a series of meaningless syllables showed a marked increase in the power of memory—no less than 33 per cent—as compared to that by individuals learning separately. Tempo, rhythm, and emphasis have a very strong influence in unifying the crowd. That which was learned separately was forgotten twice as soon as in collective work.

The interesting question has been raised as to what constituents of memory rise to the surface first in individual work and group work respectively. Dr. Moede made use of a key-word, requiring his classes to write down the association words formed in the mind consecutively. In this case the crowd performance was inferior to the individual work—the power of association being evidently much more active in separate than in collective work.

It is a noteworthy fact that in the crowd association words make their appearance which are controlled by considerations of usefulness. The key-word *stairway* suggested for example, in the course of the mental process the following words: climb, step, wood, house, bank; the key-word *sail* was followed by the words: travel, ship, boat, patch (*i.e.*, to patch a sail); the word *house* by live (dwell), yard, door, ground, etc.

The total result of these association tests indicated a stress on the emotional side of the nature in the case of crowds, and upon the intellectual side on the contrary when individuals were concerned. Here, too, Le Bon was supported in his theory that *in a crowd the intellect is inhibited or even ceases to function*, and that because of this a uniform basic mood is created in the crowd, and that this is preliminary to concerted activity, being necessary to make the latter possible.

The test with respect to the capacity for *free creation of thought* was especially peculiar in its results. The pupils in the class were told to write down all the words which occurred to them within the space of five minutes. So far as the number of words was concerned the individual yield was superior to that of the crowd. Individuals made longer lists of associated words when working alone than when working in a crowd. The individual was obviously disturbed and inhibited by the presence of the other members of the group.

It was further demonstrated that external word-associations predominate in a crowd. In the latter the association of the words was most of all governed by patriotic emotions, whereas in the case of individuals the connection between the words was of a moral or religious nature. In this exercise of making lists of words therefore the community of feeling among the workers is clearly indicated. In these tests and others of similar nature individuals exhibited a greater degree of perseverance, cautiousness and discretion, while in the case of the crowd the process of thought was more desultory and the reactions more reckless in nature.

It cannot be denied that the science of crowd-psychology has made a great stride forward through these fundamental investigations, which are of such great import with regard to collective work, whether the latter be in church or in school, in the workshop or the marts of commerce, or on the field of sport. Much ore remains to be passed through the furnace and many a vein is yet to be explored. But at all events the day of more or less barren speculation lies behind us and we are now ready to study these questions in detail.

Industrial Applications of Ozone

How This Is Produced on a Commercial Scale and Where It Is Used

By Ismar Ginsberg

IN 1783 the Dutch philosopher Van Marum, during the course of his experimentation with electrical phenomena, marked a peculiar odor in the neighborhood of his electrostatic machine, when it was operating. In 1801 Cruickshank noticed that the oxygen gas that he obtained by passing the electric current through dilute solutions of acids, possessed a queer penetrating odor. These are the first two recorded observations of the existence of the substance that is known as ozone. Neither of the two scientists, however, gave any further thought to the matter and made no attempts to determine what the nature of this odoriferous substance was. It was not until 39 years later, in 1840, that the German chemist Schoenbein investigated the matter further and found that the smell that was noticed in the air, when the latter was subjected to the discharge of an electric spark, was due to new gas, which he called ozone from the Greek "ozo" to smell.

The work of later investigators determined that the gas ozone was formed from the gas oxygen in accordance with the following equation: $3O_2$ equals $2O_3$. The significance of this equation is that three volumes of oxygen will give two volumes of ozone under suitable conditions. In the transformation, energy is consumed, which means that the potential energy in the ozone formed is greater than that in the original oxygen. This is manifested in the oxidizing powers of the two substances, for example: ozone is a much more powerful oxidizing agent than oxygen. It is seen that in the formation of ozone, no other substance is used but oxygen. Ozone is really oxygen in another form. It is what the chemists call an allotropic form of oxygen. The sole difference between the two substances is that the smallest physical unit of the gas ozone, that is the molecule of ozone, contains three atoms or three smallest chemical units of the element oxygen, while the molecule of oxygen itself contains only two atoms of the element. While this may appear to be a very insignificant difference, nevertheless it endows the ozone with very important and advantageous properties, which make it a very useful industrial reagent in many operations and processes of commercial importance.

Ozone has always existed in the air and some of the properties, which we assign to clear fresh air, are due to the ozone that is contained therein. Its presence in the atmosphere is traced to the electrical discharges during thunder storms, whereby the discharge of electricity, manifested in lightning, converts a part of the oxygen in the air to ozone. This gas is also produced in the combustion of fuels and in the slow oxidation of organic matters, as well as of certain metals, such as iron, zinc and lead. It has been found that the air contains variable quantities of ozone. In the summer time, when electrical storms are more frequent, the air contains considerably more ozone than in the winter time. Furthermore, the ozone in the air seems to increase with the altitude. The freshness and invigorating odor in the air after a storm are supposed to be due to the ozone that had been formed anew by the lightning. The bleaching of linen, when exposed to the rays of the sun, is said to be caused by the atmospheric ozone.

As we have mentioned above, ozone is a gas. It possesses a very penetrating queer odor, which has been characterized in many different ways by scientific observers. Some say the odor resembles that of sulfur, others claim that it is like phosphorous and chlorine, and still others state that it reminds them of the lobster. The odor of the gas can be detected in a dilution of one part in a million parts of air. It is colorless, but when viewed in a column of air about 5 or 6 feet long, it appears to have a bluish tint. The blue color of the summer sky is said to be due to the considerable quantity of ozone in the atmosphere at that time of the year. The principal chemical property of ozone is its strong oxidizing capacity. In this action, the ozone is converted into oxygen, while the substance that it acts upon combines with the one part of oxygen that the ozone loses. This property of the gas makes it a very powerful germicide.

There are several methods of producing ozone. It is formed during the course of many chemical reactions, as in the decomposition of persulfates, permanganates, peroxides, etc. It is produced in the slow oxidation, known as autoxidation, of various organic materials and of certain metals. It is formed by the thermal method, in which oxygen is subjected to heat under certain conditions, resulting in its conversion into ozone in the presence of different catalysts. It results from the electrolysis of various electrolytes, in which process the electric current is passed through dilute solutions of different acids, bases and salts. It is found in the emanations of the ultraviolet light. It can always be smelt in the neighborhood of quartz mercury vapor lamps. Finally, it is formed by means of the silent electric discharge. This is the sole method of producing ozone, which is of any commercial importance.

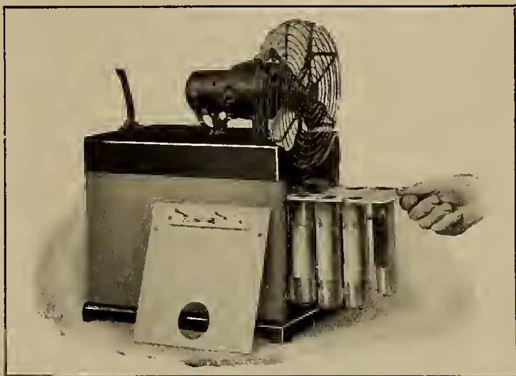


FIG. 1. TYPICAL OZONATOR OF THE TUBULAR TYPE

The industrial ozonizers are of two types, viz., one in which the silent discharge passes across the air gap without the interposition of any solid dielectric or non-conductor, and the other in which one or both of the electrodes are protected by some suitable non-conducting material, which is usually glass. The first type of ozonizers may be dismissed in a word. Attempts have been made to construct practical machines of this type, but these have been unsuccessful up to the present time, as the efficiency of these machines has always been too low to render them of any practical value. All the modern industrial ozonizers contain dielectric material.

There are two forms of machines in general use, viz., the tubular ozonizer and the plate ozonizer. The latter type is divided into two classes, those that are air cooled and those that are water cooled. In the first type of machine the ozone is formed by drawing the air through a series of tubes in which the silent electric discharge takes place. The tubes consist of an aluminum inner tube and a glass outer tube. The tubes are surrounded with water. Sometimes oil is used instead and enameled iron instead of aluminum. The plate ozonizers do not require the use of water as the radiation surface is large and the cooling effect may be obtained by the use of a current of air passing through the machine. The plates in the air-cooled plate ozonizer are made of glass and aluminum. In the water-cooled plate ozonizers the cooling is accomplished by means of running water.

Fig 1 shows an ozonator of this type. The tubes are shown exposed. The air enters at the bottom through suitable openings, and is made to pass through the space that exists between the concentric oxidizing tubes, where it is subjected to the electric discharge and part of its oxygen thrown into the ozone form. The ozonized air is drawn out of the apparatus through an opening immediately below the electric fan, and the latter drives it into the room to mix with the general atmosphere. Fig. 2 shows the tubes of a smaller machine, having only two tubes in place of the eight of the larger model. It is designed for household use; the other is for warehouses, auditoriums, hospitals, etc.

In cold storage rooms, where it is desired to move the ozonator about, the arrangement shown in Fig. 4 is very advantageous. The machine is mounted on a hand truck, with cord and plug attachment and knife switch. The ozonator on this truck will give about 700 milligrams of ozone per hour with a current consumption of 45 watts.

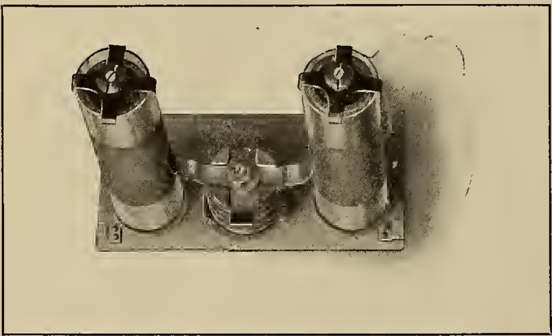


FIG. 2. A SMALLER MODEL FOR HOUSEHOLD USE

Another interesting installation is the water purifier for use with swimming pools and drinking water. Fig. 6 shows the internal construction of this. In the ozonator part of the apparatus at the left, *a*, *a*, *a* are removable trays containing calcium chloride. Air enters at *b* and in passing over these trays gives up its moisture before it reaches the generator tubes *c*. *d*. In the back of the casing there is placed a transformer *h* by means of which the line voltage is raised to the potential necessary for the operation of the ozonizer. The inner and outer tubes are plainly seen. Between them is maintained an electrical brush discharge. Air is drawn out of the apparatus through the pipe *e* by the pump *p*. This pump is provided with two cylinders. The air from the ozonizer enters the cylinder *f* and is pumped into the base of the tower T. The cylinder *g* receives the water that is to be purified, and this too is pumped into the base of the mixing tower. The pump is driven by a motor and forces one cylinder full of ozonized air and one of water into the tower at each revolution. The mixing tower is a cylindrical pipe about six feet in diameter. The water and the ozonized air are mixed therein very thoroughly, the air bubbling through the water and escaping through the opening *k* at the top, mixed with the water.

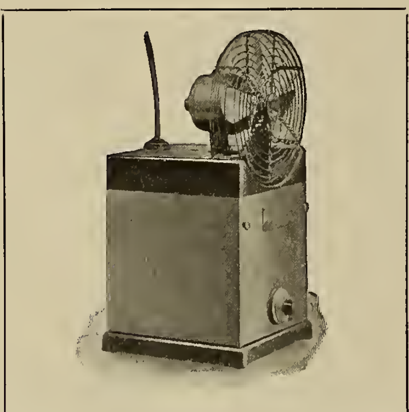


FIG. 3. ANOTHER SMALL OZONATOR FOR HOUSE AND OFFICE

Ozone has been used for a long time to purify water. It was found that water, treated with this gas, improved in taste very considerably and the impurities, contained therein, were completely oxidized, with the production of a water that can be used for alimentary and industrial purposes of all kinds. Another common use of ozone has been in the purification of air in underground passages and railways and in various public buildings, such as railway stations, theaters, etc. In order for the ozonized air to be real beneficial to the human beings who breathe it, the gas must not be present in a concentration of more than 0.11 to 0.12 milligrams per liter. The ozone undoubtedly removes the unpleasant smells which are associated with crowded places when present in this concentration, but when it is found in greater quantities, then its oxidizing action is so strong that the ozonized air has a deleterious action on the respiratory passages of the human body. The general opinion is that the presence of ozone in the air tends to destroy the disease germs that may exist therein, and it is curious to note that during the recent influenza epidemic in London, which was a part of a worldwide plague arising from the destructive results of the war, the drivers of the electric trains in the London underground railways were all immune from this disease, which was attacking both the high and low without distinction. It was conjectured that the reason for this was the fact that these workers were constantly breathing in an ozonized atmosphere all day long which rendered their systems very resistant to the influenza germ.

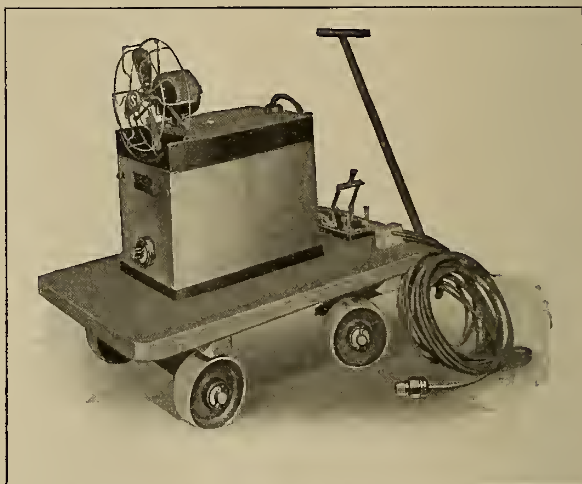


FIG. 4. PORTABLE OUTFIT FOR WAREHOUSES, ETC.

During the war the use of ozone for surgical and therapeutical purposes was given a great impetus by the difficult conditions of properly sterilizing wounds and counteracting infections in the military hospitals. In many of these hospitals small portable ozonizers were used. The results that were obtained in the sterilization of wounds by causing a current of ozonized air to pass through the cavity or sinus, were very excellent and gratifying. The first result is an increased discharge of pus, which was gradually replaced by a clear serum. The application took place twice a day for a maximum time of 15 minutes each. In all the cases treated in this manner success was attained in practically 100 per cent.

Another use is in the treatment of inflammation of the lungs. After potassium iodide had been introduced into the lungs, ozonized air was breathed and a reaction resulted in which free iodine was liberated. Ozone has been used for the disinfection of the intestines in cases of enteritis and dysentery. An important application of ozone is in the treatment of pyorrhea and ulcers in the teeth. Ozonized vaseline and other ointments have appeared on the market and are said to possess very marked advantages over the ordinary ointments. It appears that ozone is soluble in the oils that are used to make these ointments, and naturally it endows these products with a

germicidal activity which the ordinary salves do not possess. Ozone has been used in the treatment of anaemia, due to the fact that it has the property of stimulating the production of the red blood corpuscles. In asthma and heart trouble, where a shortage of oxygen is experienced, the use of ozone has been fraught with considerable success.

The use of ozone for this purpose is by no means new as far as the various textile fibers are concerned. However the application of this property of ozone in the oil, fat and wax industry is of more recent origin. There are a great many purposes for which ozone can be used in these industries besides the bleaching of the product and the improvement of its color thereby. In the case of fats and oils, which are to be used for food, a considerable improvement in flavor and taste can be achieved by the use of ozone as well as an improvement in color. Ozone has been very useful in the refining of oils and fats, which are intended for soap making. The bleaching of wax has been accomplished by the use of ozone, whereby a charge of matted wax, weighing about 11.3 kgs. and contained in a vessel, provided with steam heating coils, was bleached within 4 to 5 hours. In this process an installation of ozonizers, possessing twelve tubes in all and giving 12.5 grams of ozone per hour, was used.

In an installation of an organizing equipment used for the above purposes, the air that is admitted to the apparatus, is first passed through a cleansing device, where all the dust and foreign matter of all kinds are removed. Then it is blown by means of a fan through an air-cooling machine and thence through the ozonizers. The ozonized air is then blown through the molten fat or oil through a perforated pipe which opens out under the surface of the oil.

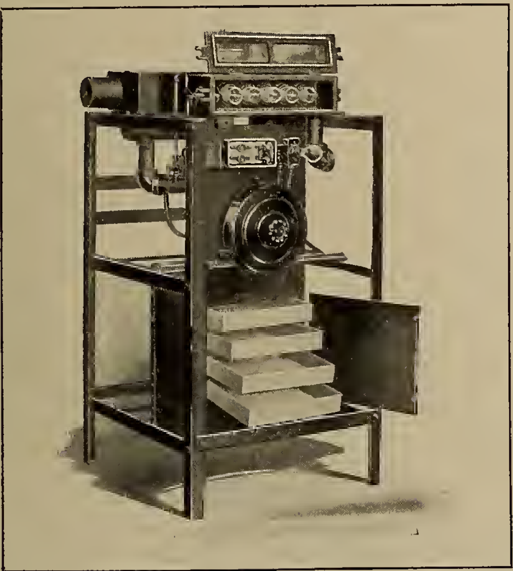


FIG. 5. TWO-UNIT MACHINE FOR INDUSTRIAL PURPOSES

OZONE IN THE PAINT AND VARNISH INDUSTRY

Ozone is of particular use not only in the manufacture of paints and varnishes but in their application as well. Ozone destroys the chlorophyllic constituents that are contained in industrial oils and waxes and that are responsible for the color of the same. Consequently, its use has been proposed in the making of clear transparent varnishes.

The drying of oils, such as are used in manufacturing paints and varnishes, is a process of slow oxidations and polymerization. This action is accelerated, as is well known, by the addition of siccatives, for example, the salts of lead, manganese, zinc, cobalt, vanadium, cerium and uranium. These substances, which are pseudo-catalytic in nature, can be replaced by the use of ozonized air. Identical results can be obtained therewith and in the opinion of some paint technologists the advantages, due to the use of ozonized oils, are far greater than any that can be obtained in other ways.

A film of paint or varnish dries hard on the exterior within a comparatively short time after it is applied. The interior of the film however remains soft for quite a long time, as the hard exterior coat prevents the access of air to the undried oil and hence delays its oxidation and drying. This is a serious disadvantage in the cases where rapid drying is necessary, and where the painted or varnished articles must be removed from the drying chambers as quickly as possible. It is claimed that when the oil is partially oxidized first by means of ozonized air, the drying of the paint or varnish proceeds rapidly and regularly throughout the entire film, so that a perfect dry coat of paint is obtained.

A particular application of this property of ozonized air is in the finishing of automobile magnetos. In the old method the magnetos, after machining, are impregnated with oil in a vacuum, so that the oil penetrates completely into the interior of each part of the magneto. During the drying operation the surface hardens, while in the interior the oil remains liquid. When the magneto rotates at great speed in its operation, the centrifugal force is often able to throw out the liquid oil and destroy the coatings. It was found that this defect could be remedied completely by ozonization. The oxidation of the oil is accomplished in a mixer by blowing the ozonized air through the oil. Under these conditions the mixture of oil and air is effected in as intimate a manner as possible. At the end of several hours the absorption is sufficient and then the armatures can be dipped in the oil with the certainty that the drying will be complete. In addition to this treatment of the oil, the magnetos are dried in a chamber which is traversed by a current of ozonized air which further assists the drying process. Pianos, varnished with partially oxidized oils, have been dried with ozonized air in drying chambers. The good results that have been obtained in this new process have been very gratifying and have led to its adoption, in preference to the old slow method of drying varnished pianos, in several plants.

Not only may oils be bleached, decolorized and rendered more siccative by treatment with ozonized air, but they may be thickened and even solidified according to the nature of the oil, the conditions under which the treatment takes place and its duration. As far as linseed oil and others of the same type, that is the ordinary drying oils, such as china wood oil, poppy seed oil, rapeseed oil, etc., are concerned, the treatment with ozonized air can first bleach the oil then increase its drying properties, then thicken it and finally cause it to solidify. These actions take place in the order indicated, which is very advantageous, as the oil may be bleached without drying the same.

The operation of solidifying the oil must take place in a mixture provided with mechanical agitators by which the oil is kept in constant vigorous agitation. Otherwise the process is prolonged for an extreme length of time, which renders it absolutely impractical from an industrial standpoint. However, when it is carried out under the proper conditions it is very easy to thicken linseed oil to a syrup or to a jelly for use in the manufacture of linoleum. The temperature at which the process is carried out is of importance. Thus boiled oil thickens very rapidly when the ozonized air is introduced into the oil, kept at a temperature of 65 to 90 degrees Cent. At the end of six to eight hours' treatment, it has solidified into a dark colored product. On the other hand when the process is conducted at a temperature below 40 deg. Cent. the solidification requires 8 to 10 hours, but in this case a bleaching effect is attained as well. The temperature at which the process is accomplished will, accordingly, be determined by the use to which the product will be put. If it is a question of making a light-colored linoleum, then a light colored solidified oil will be desirable and the longer duration process will be used. On the other hand, if a dark colored linoleum is to be made with the oil, then the process of shorter duration may be used.

China wood oil oxidizes rapidly under treatment with

ozonized air, while poppy seed oil and grape seed oil do not thicken as quickly as linseed oil. These oils as well as linseed oil, in their thickened form, are used not only in the manufacture of linoleum but also in the preparation of waterproof materials, fish netting, etc.

In the treatment with ozonized air of hydrocarbons, which are found in petroleum and are obtained by the distillation of coal, lignite, etc., and which belong to the non-saturated series, ozonides have been formed which may then be transformed into fatty acids. In Germany an oil has been obtained from lignite coal, which possesses a brown color and a very disagreeable odor, and boils at 125 to 220 deg. Cent. This oil will give ozonides which are soluble in alkaline solutions. When subjected to the action of steam, the ozonides are converted into peroxides, which react with the alkalies to form a jelly. The oils that are obtained in the distillation of schists can be treated in the same manner.

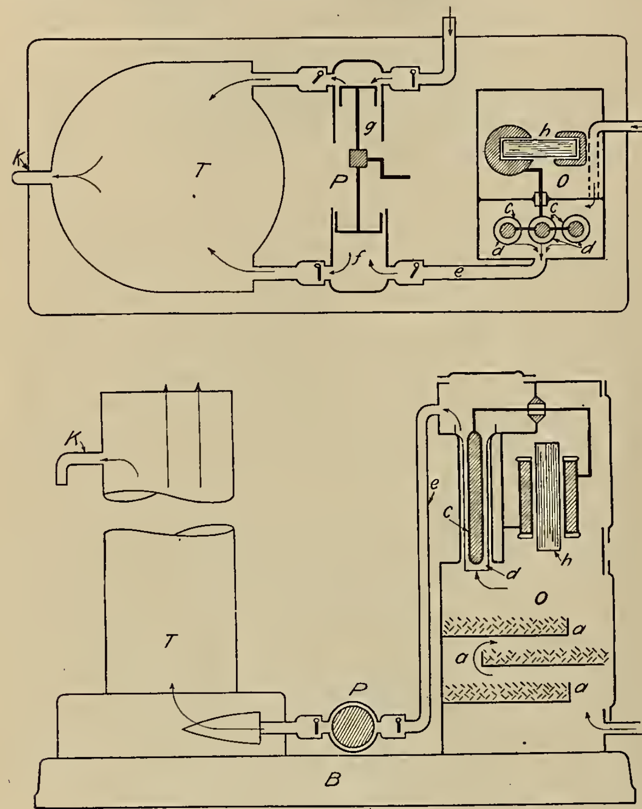


FIG. 6. THE OZONATOR INSTALLED AS A WATER PURIFIER

The process that is used in the Schurstein Ozone Works at Wiesbaden is somewhat as follows: The oils and the alkali solution are placed in tanks of 1200 liters' capacity each, which are cooled with water which courses through a water jacket, and the ozonized air, containing 2 to 5 grams of ozone to the liter of air is bubbled through. A potassium or sodium soap is formed, according to whether caustic potash or soda is used in the process. It has been claimed that from 100 tons of lignite which give 3 tons of tar from which 1.6 tons are obtained after the first refination, which will give 0.64 tons of oil to be treated with the ozonized air, a total of 0.12 ton of crude fat can be obtained.

It has been known for some time that ozone can be used to oxidize organic chemicals and its use in the manufacture of various organic compounds which are made in part or in whole by an oxidation process has been fraught with much success. It has been used successfully in the manufacture of several synthetic perfumes, such as vanillin, heliotrope and anisaldehyde. It has also been proposed to use ozone in the oxidation of aniline to aniline black, and the leuco base indigo to the colored dyestuffs.

In the brewing of beer ozone has found an application not only as a preventive in stopping the growth of foreign micro-organisms during the fermentation process, but also in the refrigeration and bottling processes. Another use of ozone is the preservation of food, especially in connection with refrigeration. Meat must be kept at a low temperature in order to prevent it from spoiling. The use of a low temperature and a sterile atmosphere as well, that is an ozonized atmosphere gives very much better results than cold air alone. Inasmuch as ozonizers are able to work best at low temperatures and as they do not occupy much space it is very practical to use them for this purpose not only in storage refrigerators but in the refrigerating cars as well during the transportation of the meat. Both the internal sources of contamination of the meat, that is the enzymes present therein that cause its decomposition under suitable conditions and the external sources of infection, such as flies and air-borne micro-organisms are destroyed or prevented from acting by the ozonized air and the low temperature.

In the drying of copra, from which we get cocoanut oil, ozone is used to advantage, as it does not give the exceedingly odoriferous product that is obtained in the ordinary sun-drying process. Another interesting use is in the conditioning of flour in flour mills. This is claimed to be attended with an increase in the mill's capacity amounting to possibly 30 per cent and in the practical elimination of the flour moth.

THE MAKING OF EDIBLE FATS FROM PARAFFINE

It was found that in the oxidation of paraffine at 135 to 145 deg. Cent. the products of the oxidation did not dissolve in soda ash but only in caustic soda. This indicated the presence of fatty substances, not fatty acids, in these products which could be used instead of the ordinary neutral edible fats. Ordinarily it has been found relatively easy to obtain the fatty acids from paraffine by various synthetic processes, but the formation of a neutral fat directly therefrom which could be used as food was not suspected as being possible. The fatty acids are unsuitable for food as such, but can be used in making soap.

The synthesis of fatty acids from paraffine has been accomplished by heating the paraffine under pressure in an autoclave in the presence of suitable catalysts, such as the compounds of the metals, Mn, Pb, Hg, Vd and Cr, and also the alkalies and the alkali earth elements. Then the fatty acid is treated with glycol in the presence of sulphuric acid and a fat is obtained. Such a fat has a cocoanut like odor and when purified is a very good substitute for ordinary fat.

The fat that is obtained directly from paraffine by oxidation does not contain any glycerine. It avoids the necessity of the use of glycol or glycerine in its manufacture. Various tests have been made by private individuals and Government and industrial organizations on the physiological properties of this substance and it has been found that the digestive organs react to it very favorably. It is absorbed into the system through the intestines, and possesses a high food value.

The process of making this product has been patented, but at the present time it has not acquired any great commercial importance. However the principles involved in its manufacture are very interesting and of considerable importance. It is probable that their application to the treatment of the higher fatty acids will result in the production of fats which will possess valuable possibilities of industrial usages as well as food values.—Translated from *Chemiker Zeitung*, 44, 309-310, 477-78.

THE DEVIATION CAUSED BY PAIRS OF PRISMS

In many optical instruments a variable angle of deviation is obtained by rotating two small-angle prisms in opposite directions about a common axis. In such a system the principal section does not maintain its position for all positions of the two component prisms; in fact, it is only in the case where the inner surfaces of the two prisms are perpendicular to the axis of rotation that one can speak of a principal section of the complete system.

Correspondence

Comment From Our Readers on Articles of Recent Appearance

STALLO AND EINSTEIN

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

In an editorial in the July issue of the SCIENTIFIC AMERICAN MONTHLY on "Mr. Maxim's Paper of 1889," occurs the following statement:

"In particular, we reprint it at this time chiefly because it contains what we believe to be the earliest unreserved statement of the universal relativity of uniform motion, with no loop hole left for the man who would like to believe that after all there is somewhere something, which, if he could only find it, he could use as a reference frame for absolute motion."

In a volume entitled "Concepts and Theories of Modern Physics" by J. B. Stallo, published in 1881 and 1884 by D. Appleton & Co. in its "International Scientific Series" the nature of motion is thoroughly discussed, and the universal relativity of all motion unreservedly advanced by the author, after reviewing the opinions of men like Neumann, Euler, Leibnitz, Descartes, Newton and Galileo. (See Chapter 12.)

The volume might well have been entitled a treatise on Relativity, for such it really is. It is a critical, although unfavorable, consideration of various theories, physical, chemical, mathematical and astronomical, then commonly entertained. The subjects considered and the conclusions arrived at are well summarized in the following passage:

"There is no absolute material quality, no absolute material substance, no absolute physical unit, no absolutely simple physical entity, no absolute physical constant, no absolute standard, either of quantity or quality, no absolute motion, no absolute rest, no absolute time, no absolute space." . . . "Nor is there an absolute system of coordinates in space to which the positions of bodies and their changes can be referred."—(Chapter 12.)

As a profound and keen thinker, and for scholarly attainments, the author, in my judgment, stands in the front rank.

Prospect, Ohio. EDWARD MAAG.

MAXIM AND EINSTEIN

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

Hudson Maxim's article of 1889, reprinted in the July MONTHLY, which claims to anticipate Einstein, is a strange mixture of a whole lot of obsolete absolutism, obsolete even at the time he wrote, with a very minute quantity of relativity. It is a curious fact that just a few pages beyond the passage in Herbert Spencer's "First Principles," quoted by Mr. Maxim, occurs a proof of the relativity of motion, that is strikingly similar to Mr. Maxim's. The passage is in part as follows:

"And so we are taught that what we are conscious of is not the real motion of any object, either in its rate or direction; but merely its motion as measured from an assigned position—either the position we ourselves occupy or some other. Yet in this very process of concluding that the motions we perceive are not the real motions, we tacitly assume that there are real motions. . . . we take for granted that there are fixed points in space with respect to which all motions are absolute; and we find it impossible to rid ourselves of this idea. Nevertheless, absolute motion cannot even be imagined, much less known. Motion as taking place apart from those limitations of space which we habitually associate with it, is totally unthinkable. For motion is change of place; but in unlimited space, change of place is inconceivable, because place itself is unconceivable. Place can be conceived only by reference to other places; and in the absence of objects dispersed through space, a place could be conceived only in relation to the limits of space; whence it follows that in unlimited space, place cannot be conceived—all places must be equidistant from boundaries that do not exist. Thus while we are obliged to think that there is an absolute motion, we find absolute motion incomprehensible."

This was first published in 1860. Yet Herbert Spencer did not put forth this theory as new, but merely as one among several illustrations of the relativity of *all* knowledge, which he was advocating. This wider theory, which naturally includes, even if not specifically so stated, the relativity of motion, dates back to the Greek Protagoras. It was the mainspring of the positive philosophy of Compte (1840). Nevertheless, many early writers specifically discussed, and unreservedly supported, the relativity of motion. The illustration of the single body in unlimited space, used by Mr. Maxim, dates back to Euler (1765).

Many of these early writers, however, while arguing for the relativity of *all knowable* motion, still admitted, like Spencer, the possibility of absolute motion. This loophole was thoroughly tamped by J. B. Stallo, "Concepts and Theories of Modern Physics" (1881). He insisted that absolute motion was not only unknowable but nonexistent. He said (p. 200): "The reality of rest and motion, far from presupposing that they are absolute, depends upon their relativity." He went still further and on page 204 stated: "The same considerations which evince the relativity of motion also attest the relativity of its conceptual elements, space and time." Finally, on page 200 he wrote: "In short, the fixity of position of any body in space is possible only on the supposition of the absolute finitude of the universe; and this leads to the theory of the essential curvature of space, and the other theories of modern transcendental geometry." All this sounds much more akin to modern relativity than what Mr. Maxim wrote eight years later.

The fact is that this philosophic relativity, upheld by Maxim and his predecessors, has nothing whatever to do with modern physical or experimental relativity. It is deduced apriori from the nature of conceptional knowledge. No possible experience can either support or shake it. It would stand though all Einstein fell. Physical relativity, on the contrary, is derived from experience. Pure thought could never without experience deduce or predict it.

There are three degrees of physical relativity: Newtonian relativity, special Einstein, and general Einstein.

Newtonian relativity is a consequence of the first two laws of motion, for according to these laws, the mechanical behavior of bodies is unaffected by uniform translation, *relative or absolute*. It is therefore derived from experience. No one could possibly predict, in the absence of experience, that physical motions depend upon differential equations of the second degree, as demanded by these laws. It is much more natural to expect the first degree, as previous notions require. This mechanical relativity obtains whether the philosophical brand does or not. How else could Newton defend absolute motion, while his laws call for relativity?

The special Einstein theory asserts that optical and electrical phenomena are similarly unaffected by uniform translation whether with respect to the ether (so-called absolute motion) or with respect to other bodies (relative motion). Likewise this was not always believed, as witness the Michelson-Morley experiment. But motion with respect to the ether is not absolute in the philosophical sense. It is still the relative motion of two material bodies, therefore theoretically detectable. Experiment alone can show that it is not. But

this ether we are obliged to consider as fixed, because of philosophical relativity. The ether as a whole which means the whole material universe, constitutes an Eulerian single body. Any motion of it would be absolute in the philosophical sense, hence unknowable. Whether such obtains or not is no concern of the physicist. Special Einstein, based on the Michelson experiment, stands, whichever way the decision falls.

The general Einstein theory results from the observation, that the conspicuous mechanical effects accompanying a variation of velocity, can equally be well accounted for by supposing the system on which they occur to be entering a field of force, or more exactly a region where space is distorted by the presence of other bodies. The two hypotheses being indistinguishable, one cannot on the basis of these effects alone, unequivocally assert that his velocity has changed. He must look out and observe the other bodies. The only doubt about the complete validity of this "principle of equivalence," concerned the behavior of light. But the eclipse expeditions showed that the behavior of light is percisely the same as that of mechanical bodies, hence like them gives no unambiguous indication. This relativity then of variable motion is likewise based upon experiment, unforeseeable, undeducible. It is change of motion relative to the rest of the world, not of the world as a whole, that is thus experimentally shown to be indeterminate. It too is therefore independent of philosophical relativity.

Therefore neither Maxim, nor even Stallo, nor any of the innumerable other staunch supporters of the ancient philosophical relativity can be conceived to be in the least precursors of Einstein. If that were not so, I might legitimately claim to be myself such a precursor; for I find in notes written in 1903, discussion of, and unreserved adherence to, the relativity of motion. M. C. MOTT-SMITH.

Los Angeles, Cal.

THE LEGENDARY ISLANDS OF THE NORTH ATLANTIC

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

I have been very much interested in reading articles under the above title on the "Legendary Islands of the North Atlantic" by Albert A. Hopkins, in the July issue of the SCIENTIFIC AMERICAN MONTHLY.

It puts me in mind of a lecture which I heard some years ago by Dr. Ronald Strath in Seattle, who had spent some time in Yucatan studying the prehistoric monuments and inscriptions of the Mayas in the jungle. According to Dr. Strath, whose lecture made a vivid impression on me at the time, these inscriptions, which are very voluminous and were then by no means completely translated, gave a complete and very detailed description of the destruction of Atlantis, by a planetoid grazing the surface of the earth, and raising such a heavy cloud that the earth was dark for eighteen months. As I remember it, the date of the catastrophe was also set by astronomical data at about 13,000 years B.C.; and that the earth comes into imminent danger of another similar catastrophe about every 52,000 years.

The inscriptions, if his interpretation of them is correct, give a marvelously complete history of events of the people of Atlantis over a period of several thousand years, together with an account of their social and religious institutions, etc. I was particularly impressed with them by reason of accounts given of struggles over many social problems, such as woman's suffrage, which are supposed to be distinctly modern in character. I also remember an account of a system of suffrage which was worked out, whereby both men and women could vote; but the weight of vote was varied with different individuals of different ages and attainments. Thus an elderly man of experience in affairs exerted more influence than a young man just old enough to vote. There were also many laws, which for simple yet effectve justice in a fairly complicated society, are certainly not equaled in the present day. Their code was evidently the basis for the code of Hammurabi of Babylon, who lived at the time of the scriptural Abraham, and who compiled the earliest hitherto known historic code of laws.

According to Dr. Strath, who I believe had also been in India and Asia as a British Army surgeon, and had made a study of archaeology in those places, the civilization of Atlantis was the parent of the old world civilizations; and the old world nations were founded as colonies of the people of Atlantis. He showed how the architectures of Egypt, Babylon, Ancient Greece, etc., are plainly developments of the architecture of Mayapan, which was the architecture of Atlantis. He showed a photograph of a sphinx in Mayapan very similar to that of Egypt; and told of an account in the inscriptions of Mayapan of the building of the Egyptian sphinx by an exiled queen of Atlantis in memory of her assassinated brother.

He also showed a connection between the Atlantian language and the parents of the civilized languages of the present day, with intent to prove that the Atlantian language, as shown in the inscriptions of Mayapan was the parent language of the modern languages.

I am a layman in the subject at hand, and not in a position to judge of the reliability of Dr. Strath's work. If reliable, it should set at rest forever any question of the authenticity of the Atlantian legends. The inscriptions, illustrated in the lecture, are certainly far too voluminous to have been the result of any hoax. I have also seen other pictures of the same monuments and inscriptions elsewhere. An engineer of my acquaintance has made a number of pleasure trips to Mexico and Central America, and has also obtained a collection of very fine photographs of some of the monuments and inscriptions of Central America. While he obtained them simply as curiosities, and seems to have little idea of their significance, I have no doubt that he could be influenced to publish them, if they would be of interest, without explanation or attempt at interpretation.

Dr. Strath also referred me to a book by Le Plongeon (initials of author and title of book forgotten). I borrowed it but was unable to read this work at the time, though I glanced through it; and made out that in general it seemed to confirm Dr. Strath's conclusions very closely. I have never been able to obtain the book since.

An interesting feature in connection with the account of the destruction of Atlantis by a planetoid, is the fact which I read in a book on geology when a boy, that the geological formation of the diamond fields of Brazil and of Africa can only be accounted for by such a catastrophe as is described in the account of the destruction of Atlantis. Any physicist knows that diamonds are only formed under the intense heat and pressure that such a catastrophe would entail.

It is also interesting to theorise on what would happen to the earth in the event of such a catastrophe and compare that with legendary accounts; the intense heat of collision, though the blow was only a glancing one, would vaporize vast quantities of the water of the Atlantic, which with, clouds of fine ash would be carried in the atmosphere all over the surface of the earth and literally darken the sun. The whole earth would quake and would continue quaking until the maladjustments in the crust brought about by the strain had again become adjusted. Volcanic activity would everywhere tend to increase. On the cooling of the evaporated ocean waters, rains of violence never before or since equaled would cover the earth. There could easily be wide changes brought about in the elevation of lands and the outline of coastal shores. Many things that have puzzled geologists could easily be explained by such a catastrophe. The Sahara desert has never been satisfactorily explained, I believe. It would not take a very large asteroid to accomplish such a result; indeed the collision of one of the larger of them would probably destroy all animal life on the earth, so great would be its disturbances. But it occurs to me that some of our astronomers could furnish information bearing on the matter, by telling us whether there is any known asteroid whose path came close enough to the earth at that time for a collision, and whether there is any-

things in the legend of a 52,000 year periodicity of danger of such a collision with the earth.

If I recall my astronomy correctly, this is approximately the period of the spinning of the earth's axis with relation to the plane of the earth's orbit. It is well known that some of the asteroids have orbits of such eccentricity as to pass close to the earth's orbit. It might well be that one of them would cross the earth's orbit at the time when the earth happened to be close enough to draw it into collision only once in 52,000 years. Certain of the ancients had a wonderful knowledge of astronomy; it is not impossible that they could compute orbits.

I am also inclined to wonder whether the Sargasso Sea—that refuse heap known to mariners of the flotsam of the Atlantic, brought by wind and current from all parts of the ocean, is not responsible for some of the legends of floating islands in the Atlantic. It certainly has an appearance which might easily give the impression of a floating island.

However, this is all speculation. The great pity of it all is that knowledge has reached the point where it takes all of a man's life to obtain a complete knowledge of one subject, let alone sufficient of others to be able to correlate them and obtain really sound conclusions. Scientists used to trace consanguinity of races by lingual similarities, until so many cases of the imposition of the language of one race upon a totally alien race came to light that language was seen to be a totally inadequate basis for their work. But similar conclusions are being drawn from equally inadequate bases in nearly all research work nowadays. The natural sciences, it is true, are beginning to draw together. But the process is but beginning. And we still have the geologist drawing conclusions which a little knowledge of astronomy or of physics shows to be unsound, the biologist working blindly at a problem which a knowledge of chemistry would immediately solve, the Freudian psychologist drawing conclusions utterly at variance with anthropology and history. Not only are research men unacquainted with the work in other sciences, but so many of them are utterly lacking in that quality of sound judgment brought about by contact with human affairs, which is called common sense. So many of them are prone to go mooning about their specialties in utter oblivion to all that is going on in the great and wonderful world around them, and become unbalanced to the point where they are incapable of sound judgment even in their own specialties, however wonderful their detailed knowledge of those specialties may be. I know, for I have several scholars among my immediate friends and relatives and am only too well acquainted at first hand with the narrowness and jealousies of some of them, and how directly it affects their work. My father repeatedly has taken part in faculty meetings of one of our institutions, wherein the curricula of the students are determined. Such meetings become scrambles in which each professor is intent only on seeing how much of his particular specialty he can jam into the curriculum. Nor is this particular institution any marked exception. I have heard of the same thing in one of the foremost universities of the country. [*We have seen it in such a university.*—The Editor.]

What we need in all research and scientific teaching is executives who are not specialists, but who have enough of the knowledge of each specialty to be able to correlate and direct all of the departments to a common end. They should have authority not merely to take haphazard findings and correlate them, but to direct the work for a given end. If, for instance, it is desired to establish the authenticity or non-authenticity of the legends of the lost Atlantis, the work should be in charge of a man of broad education and executive power. He should have authority to direct a geologist, an astronomer, an architect, a linguist, a historian, a specialist in folk-lore—in short a representative of every science remotely bearing on the subject—and get them to dig into the evidence bearing on the subject from all the different angles. With all of their results at hand, he is then in a position to form sane conclusions. There are scarcely two sciences in human knowledge that do not have some facts bearing on each other. None can reach their highest development without the aid of the others. All will in the end be found equally worth while for human advancement.

The organization of research I propose has already been used in the Rockefeller Foundation and other similar institutions with results little short of the marvelous. It is the same organization which is used on every big construction or industrial enterprise. An executive is placed at the head, who has sound judgment, and a sufficient knowledge of all of the processes under his control to be able to direct and coordinate his specialist subordinates and check them against each other. He should have, and usually has, the greater human ability, if I may coin the phrase, while there is probably not one of his subordinates who does not know more about his own individual specialty than the executive does.

Why is it that the process of the advancement and dissemination of human knowledge is a whole age behind every other phase of human activity, and is still largely left to individual initiative, while cooperation is the watchword of nearly every other phase of civilization?

Onekama, Mich. Leo G. Hall.

AN ECHO OF THE EINSTEIN CONTEST

To the Einstein Editor:

Many thanks for the complimentary copy of the book on Einstein's Theories. Outside of the strictly mathematical memoirs on the subject this book gives the clearest and most adequate treatment of the essential features of Relativity that I have seen—and I've glanced over several.

I agree heartily with the judges that Einstein's theory is best presented for laymen in Bolton's essay. Yet I make a mental reservation—as do you—that Murnaghan's contribution is easily first for those who will take the pains to study it. I particularly admire the essayist's nerve in writing for a popular prize competition an article that is of interest and value for adepts as well as for beginners. The long and the short of it seems to be that persons who are too inert to master the rudiments of analytic geometry can form no definite conception of what Einstein has done.

It is too much to hope, I fear, that someone as generous as Mr. Higgins will pay a competent geometer to write a college text-book on the absolute differential calculus. The sale would be limited, but such a book must be available if America is not to sit permanently on the back seat of modern mathematical physics. Such a book should contain scores of drill exercises and should be written so that science and engineering students could read it. Dozens of Americans are competent to write such a text. The material at present is so widely scattered that it is inaccessible to all who are not near a university library. E. T. Bell.

University of Washington.

[*Dr. Murnaghan himself, so he informs us, is at work on a volume which will fill at least part of the field which Dr. Bell justifiably feels to be so vacant. Judging from his Einstein essay, this book ought to be thoroughly good; we shall announce in the* Scientific American *its publication, giving it a place of sufficient prominence so that nobody who is interested will have any difficulty in finding it.*—The Editor.]

THE DEADLY X-RAY

To the Editor of the Scientific American Monthly:

I have read the paper in the Monthly for August giving Contremoulins' thoughts on the fatal power of X-light. The paper is chiefly interesting as illustrating how difficult it is for an independent experimenter to get his results noticed until they are restated by some one within the academic circle, composed of men who work professionally on that special subject. Soon after Roentgen's discovery that some of Lenard's rays would show the bones of the hand, Elihu Thompson

proved by a carefully planned experiment that these X-rays would burn the skin. A statement from so distinguished a man, though not a physician, should have been heeded by the medical profession and proper precautions taken, thus saving many lives. Soon after another experimenter, also outside the academic circle for this particular subject, proved by many experiments on animals, if proper filters were used to strain out the long waves, which he found were the ones producing the effects on the skin, that blindness, sterility, abortion and death could be produced by X-light of shorter waves (without external injury).

Later some of the results were printed in the Boston *Medical and Surgical Journal* for February 14, 1901, to bring them to the attention of physicians. The conclusions that were drawn from these experiments as to the imperative need of protection from X-light had been previously published in the *Electrical Review* for April 11, 1900, and later in the same journal for March 9, 1901; *Boston Medical and Surgical* for January 9, 1902; April 24, 1902; *Electrical Review* for June 14, 1902; April 4, 1903; *Boston Medical and Surgical Journal* for October 1, 1903; and finally in the *Electrical Review* for December 12, 1903 a long list of X-light axioms covering the subject was printed.

What was the result of all this labor for humanity? The papers were wholly disregarded and as a result almost all of the persons using X-light at the time are dead from its effects, while the writer who used the precautions he advised is free from any effects from X-light, though in the experiments he used a generator that produced a light that showed clearly the interior of the body in the cryptoscope used in the examinations, at a distance of 13 meters. Generally this academic neglect of outside work in science is of small importance, as human life is not involved. At the worst it only delays progress. I have a list of many such cases, as early in life I observed this curious phenomenon. One is mentioned as a good illustration. A monk revolutioned biology but the academical biologists took no notice until one of their circle restated the matter many years after.

William Rollins.

Tamworth, N. H.

VOWEL ANALYSIS

To the Editor of the Scientific American Monthly:

If you will permit me to refer at this late date to Professor Scripture's articles, which you reprint from *Nature* of the 13th and 20th of January, on the "Nature of Vowel Sounds," I should like to emphasize the great service that the writer has done in pointing out that the ordinary methods of Harmonic Analysis are not necessarily adequate for the determination of the composition of a given tone, and may indeed give quite a false representation of the facts, because the sound may have inharmonic components. At the same time, it is doubtful whether his note in a later issue in reply to another correspondent, interpreting some of Professor Miller's results in this field, are justifiable. Professor Miller's curves are evidently harmonic, from the fact that they repeat themselves very faithfully at regular intervals, and establish without much doubt that vowel sounds (and some others) at least *can be* so produced that they are susceptible of harmonic analysis, whether they are always of such nature or not. The fact that Professor Scripture finds the quality of the voice constantly changing in speech is not a matter of surprise, any more than that the human face and form rarely remain exactly the same for two seconds at a time in waking hours; it need not preclude us, however, from seeking to maintain a given quality for a time for purposes of analysis and record, any more than the latter fact prevents us from sitting for portraits.

There is, however, a point in the article that is open to distinct criticism. The writer says, "In the analysis of vowel waves the fundamental is indicated as weak or often almost lacking. We all know that this is the strongest tone of all." It takes all the point out of scientific research if we are going to discard its plain results for what "we all know," especially if the fact of "knowledge" stands on such weak grounds as does the one here referred to. All that we are justified in saying is that a complex note is by common judgment considered as having the pitch of its fundamental; this may happen in cases in which the fundamental is known to be weaker than the upper partial or partials—a fact for which we have the authority of Ohm, Helmholtz and Lord Rayleigh (Theory of Sound, Vol. 1, Sec. 26). When Professor Scripture states that fundamentals are "not of the nature of sine vibrations," he deprives us of any rational definition of the term; we could build up his type of fundamental vibration from a number of sine vibrations of shorter period and thus produce a sound of low pitch from a number of high-pitched ones.

What I believe to be the true interpretation of Professor Scripture's results and those of others in this field, in fact the inescapable conclusion, is that the fundamental is indeed extremely weak in many of the tones produced by the voice and other musical instruments, and that it is further masked in the records by the comparative lack of sensitiveness of the ordinary recording apparatus in the lower ranges. We must then also conclude that there is something in the physiology or psychology of hearing, or both combined, whereby the lowest component of a complex tone, the fundamental, fixes for the hearer the pitch of the whole tone, while the presence or absence of certain upper partials, and their relative strength, determines its quality.

The glottal puff theory is not inconsistent with the harmonic theory. Helmholtz accepted it and stated it very clearly, as seen in the following extract from his Tonempfindungen (Ellis's translation, p. 103); "In order to understand the composition of vowel tones we must in the first place bear in mind that the source of their sound lies in the vocal chords, and that when the voice is heard, these chords act as membranous tongues, and like all tongues produce a series of decidedly discontinuous and sharply separated pulses of air (luftstosse), which, on being represented as a sum of simple vibrations, must consist of a very large number of them, and hence be received by the ear as a very long series of partials belonging to a compound musical tone." There remains to be applied a positive test to determine whether or not Heinholtz was right in concluding that the partials of the voice tones are harmonic.

With reference to another point in the articles, it seems to me to be no more justifiable to say that the difference between the voice of a Caruso and that of a costermonger lies solely in the vocal chords, than it would be to say that the tone of a reed instrument depends only on the reed, without reference to the size, shape, material, etc., of the rest of the instrument, *e.g.*, that the difference between a bassoon and an oboe is only a difference of reeds.

Clark University. Preston Edwards.

COMPARISON OF STEAM AND ELECTRIC AUXILIARIES

In *Nautical Gazette* for March 12, 1921, a comparison of first and working costs for the two types of auxiliary machinery on shipboard is given. In the matter of first costs it appears that electrical auxiliaries are about 20 per cent. more expensive than steam except in the case of deck winches, where the difference is 100 per cent. The author, however, considers these differences are largly due to the fact that in many instances full development costs have been charged against the first installations of electrical gear, and with future installations and more complete standardization this excess charge would gradually disappear. Some of the advantages claimed are: (1) Absence of heat in spaces adjacent to the various auxiliaries; (2) elimination of accidents due to freezing and bursting of steam pipes, etc; (3) reduction of vibration and noise, and hence increase of habitability, especially with steering gear; (4) flexibility and simplification of control.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

TOPOGRAPHIC MAPS: WHAT THEY ARE, WHO USES THEM, AND HOW

By H. P. Little, Secretary, Division of Geology and Geography

Many geologic and geographic facts are adapted to mathematical treatment; the data resulting from such studies can readily be plotted on a map, provided they are related to some definite geographic point. After they have been plotted it is frequently advantageous for purposes of interpretation to connect those having an equal value. The resultant lines usually are given some name of Greek derivation which expresses concisely and accurately the phenomenon with which they are connected; to this word is added the Greek prefix "iso"—meaning equal, and presto, the line through its name interprets itself—if you know your Greek. The following is a concrete example: Every boy who read sea stories knows that when the captain of the good ship Adventure is expecting a storm he keeps a weather eye on the "glass." A meteorologist, though observing the same instrument, would consider he was watching the "barometer." If asked why he used so strange a name he might suitably reply that since the instrument was for measuring atmospheric pressure, and since the Greek "barus" means "pressure," and "metron" a measure, it might be that his term was really a better one than "glass." If the meteorologist kept careful records of the readings of his instrument he might plot the varying pressure on the ship's chart; later he might connect the points of equal pressure by lines and thus he would obtain "isobaric lines" or "isobars" which are just what the word says they are—lines every point on which has the same pressure.

And so it is with many other similar words of the scientist which seem needlessly long to the uninitiated—each one really speaks for itself of the reason for its being. Among a host of such *iso-* words are isonephal lines, connecting points of equal cloudiness; isoseismal lines, connecting points of equally intense earthquake shock; isothermal lines, connecting points of equal temperature; and isobathythermal lines, connecting points of equal temperature at a given depth. Each word says for itself just the meaning given it above.

Such lines, when drawn and carefully studied, often have great practical value. For instance, after the temperatures and atmospheric pressures at numerous selected stations in the United States are plotted on a map, the corresponding isotherms and isobars may be drawn. These lines are the fundamental data of the weather map on which the forecasters of the United States Weather Bureau depend when they make the weather predictions which are published broadcast by the newspapers of the country, read by millions, and heeded by thousands as they direct their ships, watch the grain market, prepare for floods, or make ready to fight the frosts of spring and fall. But this is not a dissertation on weather maps.

Isohypsometric lines are lines connecting points of equal elevation above sea level. They are one of the few *iso-* lines which have a popular synonym. This is *contour* line, a word derived from the Latin through the French and meaning to "turn with," or "encircle"; it tells what the lines do rather than what they are, for a contour often winds in and out among the hills and valleys just as would the ocean if its level should be raised by the pouring in of huge volumes of water through the melting of enormous masses of snow and ice.

A contour line has a real reason for being just as have the isotherm and isobar, and that is to tell the height and shape of the land. The better known methods of representing these features have been by coloring and shading; but neither of these approaches the contour in precision. Those who take the trouble to learn how to use a contour map for these purposes are enthusiastic over its superiority. A few simple rules for the beginner to bear in mind as he studies his map follow: (A map showing the contours of your local region can, if published, be obtained for ten cents from the Director, U. S. Geological Survey, Washington, D. C. The Map Information Office, Department of the Interior, Washington, D. C., will be glad to tell you about government maps available for your section.)

(1) When contours are close together, slopes are steep and vice versa.

(2) When a contour takes the form of a ring, it represents a hill. The greater the number of roughly concentric circles, the greater the height of the hill on a given map.

(3) If successive contours enclose greater and greater areas, the direction of movement is downhill; vice versa, the direction of movement is uphill.

(4) If the bend of a contour is toward higher land, as determined by rule 3 the land marks a valley, at least an incipient one; vice versa, the bend represents a spur or, if inconspicuous, at least a divide between small streams. The nicety of interpretation of the minor bends is a most important factor in determining the details of the land surface from the map. The vertical distance which separates adjoining contours, known as the contour interval, is increased or diminished according to whether the area mapped has great or slight relief and is usually a fixed value for a given map. It is by counting these intervals that the elevation of any point above a known elevation is obtained. To facilitate this calculation every fifth contour is made wider and its height above sea level indicated; further aid is given by stating the exact height in feet at various important points on the map. By these means many maps of the eastern part of the United States allow the elevation above sea level of any point to be obtained within 20 feet; there are comparatively few sections of the entire country, so far as mapped, for which the elevation cannot be obtained within 100 feet.

Before pursuing the subject further the customary distinction between *contour* and *topographic* maps should be made. Contour maps strictly show relief only; topographic maps show relief (*i.e.*, contours) usually in brown, hydrography (*i.e.*, rivers, lakes, canals, etc.) usually in blue, and culture (*i.e.*, the works of man except as they concern the elevation of land and the distribution of water) in black. This is the map which will be our concern for the remainder of the article.

The average person has no conception of the multitude of uses to which the topographic map can be put, or the wide variety of interests to which it makes appeal. There exists at the present time, for the purpose of increasing efficiency

and eliminating duplication, a Government Board of Surveys and Maps, composed of representatives of fourteen Bureaus which use and make maps—predominantly topographic maps. Associated with this Board, at the Board's request, is an Advisory Council to which twenty-two map-making and map-using organizations have elected representatives to serve the public interests. Included are such bodies as the American Automobile Association, American Forestry Association, American Association of Mining and Metallurgical Engineers, American Society of Agricultural Engineers, Appalachian Mountain Club, and the Association of State Geologists, with others equally well known. Surely a numerous and diverse clientele has opportunity to voice its sentiments. The Board and Advisory Council have recently prepared a memorial setting forth the various uses to which topographic maps can be put. Although the list is long, it is sufficiently instructive to merit a summary. Non-Federal uses are grouped as follows: Public utilities, industrial development, highway construction, transportation needs, use of water resources, drainage, agricultural development, development of mineral resources, utilization of timber resources, utilization of grazing resources, educational uses, popular uses, statistical uses, and national defense. Federal uses show the following grouping: The Geologic Survey in its Geologic and Water Resources, Branches and Land Classification Board; the Department of Agriculture in its Forest Service, Bureau of Public Roads, and Bureau of Soils; the Department of the Interior (exclusive of the Geologic Survey) in its Reclamation and National Park Services and the Office of Indian Affairs; the Post Office Department in its Topography Branch; the Federal Power Commission; and the War Department in its Corps of Engineers, Field Artillery, Coast Artillery, and Air Service.

Concrete illustrations of the manner in which topographic maps apply in these varied fields are at hand. In the case of public utilities, a prosperous Connecticut city wished a supply of water, and $10,000 was spent in examining possible sources; later the area was mapped and the City Engineer by inspection only was able to "discover a better supply which the city is now using, and the preliminary survey did not cost the city a cent." In extending the water supply of New York City by the Catskill Aqueduct, topographic maps saved "hundreds of thousands of dollars and years of time. . . ." Industrial uses are many. A business man from the State of Washington wrote that one of the maps was expected to save his company $10,000. The total cost to the Government of making this particular map was $8000. Another company in the same state finds that a course for a transmission line can be laid down from inspection of the map, using data it would take several weeks to compute in the field.

One of the great expenditures in this country in the next few years will be for road improvement. Statements of the value of topographic maps for this work are embarrassing in the richness of their testimony—all should be heard. One says that the value of a complete map of the state would be "worth the cost of completion to the Highway Commission alone. . . ." In another case "we spent two to two and one-half weeks in determining a line of road which could have been determined in ten or fifteen minutes if we had had maps of that area." Again, the "state is very mountainous and the reconnaissance survey for our highways has to be made by inspection of all the country. If topographic maps were available considerable territory could be discarded by a careful study of them." The best route for a railroad may be similarly estimated. From the Cadiz, Ohio, sheet, was projected a new location which affected "a saving of 2,200 feet in distance and 75 degrees of curvature, besides eliminating 600 feet of tunnel." The saving was at least $85,000 through a map costing the Government $4000 to make.

Water resources offer many problems. Estimation of water power is one. The Maine Water Power Commission requested the advice of the Engineering Council and was told that before a final analysis of the state's water power resources could be properly formulated more of the state should be mapped, since the topographic map shows "the extent of the drainage area, the configuration of the land, the fall of streams, the location of reservoir sites, and many other data valuable in the consideration of water power." Similar facts are evidently requisite for the proper reclamation of arid lands. Use of the maps in planning supplies of drinking water has already been described. Closely allied in its problems to getting water is getting *rid* of water. The people of a certain town wanted to drain a pot-hole, but were made to believe that a large lake would run into the ditch. Inspection of a map instantly showed the large lake to be 60 feet lower. Everyone remembers the great Dayton flood of 1913 with its loss of life and its $100,000,000 damages. Plans were at once started to prevent a recurrence of the disaster through the development of storage reservoirs. Probably six months of calculation were saved through the aid of existent topographic maps.

That fundamental industry, agriculture, also profits from topographic maps. The Bureau of Soils shows kinds of soil by a colored overprint. But whether the land is level or rough, on the side of a bluff or in a marsh, is just as important. So it happens that a prospective settler writes to a Commissioner of Agriculture, "I am looking for the best location to secure a homestead by purchase under the U. S. Homestead Law. . . . Any maps showing topography which you can send me will be much appreciated." Whether the land can be drained by ditching will also show, and whether it could be worked by modern machinery. One enterprising mercantile firm gives its farmer customers topographic maps of the local area which they appreciate far more than an almanac or calendar.

Mineral resources, timber resources, grazing resources, statistical uses, national defense, uses by Government Bureaus, educational uses, popular uses—these still remain. Only the last two can be discussed. How do these maps directly affect you and me who are neither engineers, nor capitalists, nor military men? They affect us in many ways. In schools and colleges topographic maps are widely used in courses in physical geography and geology to give the student practice in interpreting the origin of land forms. Usually he cannot go to the famous locality, but the famous locality can be brought to him through the map. Soon the lakes of Maine, the peculiar hills of Boston Harbor, the barrier beaches of Atlantic City, the elongate ridges of the Appalachians, the bayous along the Mississippi, the dunes of Michigan, the gorges of the great plateaus, and the cirques of the Sierras all tell their story.

To the automobile tourist or the humble "hiker," these maps are also of much value. Every bend in the road and every house is located, while contour lines show the grade of the road and the character of the back country. If the region is arid, springs are shown; if humid, every little brook, where the fish might lurk. Prospector, hunter, camper, all use the maps.

Yet, strange though it may seem, while the Government has been making specific appropriations for topographic mapping since 1889, only about 43 per cent of continental United States, exclusive of Alaska, has been mapped, and only 35 per cent at all adequately. All of the important European countries are far ahead of the United States in this respect; mapping of most of them has been completed. At the past rate of progress the United States will not complete the task for from 80 to 100 years. Meanwhile, all the various uses above described are impossible of application over much of the country, and the wasteful method of having each interest make its own map must be followed. And this in spite of the fact that a little more than the cost of a single battleship would, as shown in a carefully prepared budget, complete the task in 20 years. There is at present hope that the work will really be done in this time. The Temple Bill, now before a committee of Congress, contemplates just such a program, and the Geologic Survey could find, with the added help of topographers trained during the war, the staff to do the work.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

THE RATE OF GROWTH OF THE DOMESTIC FOWL

In an article in the *Journal of General Physiology* for July 1921, Dr. Samuel Brody of the University of Missouri Agricultural Station presents the results of observations on the rate of growth of the domestic fowl.

If the weight of a mammal, for example the mouse, is plotted against its age, the resulting curve will be seen to show three fairly distinct waves, oscillations, or growth cycles. These waves or cycles are still more strikingly shown by plotting the velocity of growth against the age.

Robertson found that the growth of each of these cycles can be represented by the equation of an autocatalytic monomolecular reaction. This fact, and the theories developed from the fundamental studies on cell growth by Sachs, Morgan, Driesch, Boveri, and Loeb, which were reviewed in a previous paper on the growth of the dairy cow, led Robertson and Ostwald to assume that the limiting factor of growth of each cycle is an autocatalytic monomolecular reaction. Assuming this tricyclic and autocatalytic theory of growth to be true for mammals, it becomes of interest to find out whether the same does not also hold for birds.

One table presented by the author shows the rate of growth of the Rhode Island Red breed of fowl from the time of hatching up to the age of laying. This figure clearly shows the rate of growth to increase from the time of hatching up to about 8.5 weeks of age when the rate of growth is at a maximum; from this maximum at 8.5 weeks the rate of growth decreases to a minimum at about 14 weeks. This is followed by another cycle with a maximum at about 18 weeks of age ending somewhere between 24 and 28 weeks of age when growth of non-fatty tissues probably ceases. That each of these postembryonic cycles follows the equation of an autocatalytic monomolecular reaction can be seen from their shape. Essentially similar results were obtained with other breeds of fowl such as the White Leghorn, single comb White Leghorn, and White Plymouth Rocks, the several breeds differing only with respect to the several constants.

The author concludes that if the tricyclic theory of growth is also true for the bird, then the fowl must go through a complete cycle during its embryonic period of growth.

Summarizing his results, Dr. Brody finds that the growth period of the domestic fowl is analogous to that of the mammal, being composed of three, or perhaps four, cycles; two of these cycles are postembryonic with maxima at about 8 and 18 weeks varying somewhat with the breed and two, or at least one, are embryonic with maxima at 11 to 12 and 15 to 16 days of age. Hatching occurs during the first part of the second or third cycle resembling in this respect the guinea pig rather than the mouse. The velocity curves of each of these cycles are similar to and can be represented by the equation of an autocatalytic monomolecular reaction.

TESTS OF MUSCULAR EFFICIENCY

In an interesting article in *Physiological Reviews* for July, 1921, Mr. E. G. Martin of Stanford University presents the results of investigations on various tests of muscular efficiency, and among them the resistance strength test. This test which differs from other dynamometric tests in that it depends upon overcoming the resistance of the subject rather than upon the exercise of active effort on his part, was developed primarily as an aid in the after-treatment of infantile paralysis and demonstrates its value in that connection. It proved to have certain advantages as a dynamometric test of efficiency and has been utilized in various fields, among which may be mentioned industry (the relation of muscular strength to industrial efficiency), and medicine (in connection with the diagnosis and treatment of "effort syndrome"). Inasmuch as jobs involving manual work nearly always make certain definite demands on the strength of the workers, it is obvious that classification of the workers in accordance with their strength may prove useful. It is true that intelligent employment managers and foremen usually decide on the basis of general observation whether individual candidates are physically equal to the demands of jobs to which it proposed to assign them, but actual strength tests should be useful in supplementing such rough and ready judgments. A more important use for them appears in connection with determining as to whether a man who has been at a certain job for a period is actually measuring up to its requirements. The finding previously referred to that there is a "standard strength" for each job, together with the further observation of Martin that operatives on jobs for which they are physically not suited develop a condition of "staleness" in which they make a strength showing definitely below that of normal healthy adults, offers a means through the strength test of discovering such conditions and rectifying them before injury is done to the operative.

A second industrial application of the strength test is found in the fact that physical condition as indicated by the strength showing tends to bear a definite relation to the industrial efficiency as expressed in output. It appears that external conditions such as temperature, possibly humidity, light, dust-laden air, and other environmental factors, may modify the physical condition as determined by the strength showing. Opportunity is afforded by means of the test to evaluate these factors as well as to form judgments as to the success of remedial measures adopted.

The strength test appears also to have a certain value in connection with estimations of industrial fatigue. Satisfactory criteria of fatigue are so difficult to obtain, that any method which promises to give reliable information on the subject is worth taking into account. The industrial studies of Martin suggest that although the strength showing is not to be looked upon as indicating invariably the presence or absence of fatigue in individuals on single days, it is a fairly reliable index of fatigue of groups or of individuals over a long period, and that where conditions are present which tend to cause entire groups of operatives to experience fatigue, the strength test has utility in their discovery and elimination.

STUDY OF THE RELATION OF THE LENGTH OF KERNEL TO THE YIELD OF CORN

In the *Journal of Agricultural Research* for July, 1921, Mr. C. C. Cunningham presents the results of elaborate experiments to determine the relation of the length of kernel to the yield of corn. Among corn growers there is a prevalent opinion that length or depth of kernel is a very desirable character in corn (*Zea mays indentata*) and that short kernels indicate deterioration. Roughly dented kernels are usually long and, therefore, this type is given preference by most growers in selecting seed corn, while smoothly dented ears are avoided.

Apparently the relation of the length of kernel to the yield of corn has not been investigated directly.

An experimental project was put under way at the Kansas Agricultural Experiment Station in 1916 to secure some data concerning the relation of length of kernel to the yield of corn. Commercial White, a medium large variety well adapted

to growing on productive soils in eastern Kansas, was used. Three 40-ear lots of corn were selected. One lot was made up of ears with kernels that were relatively short, one of ears with kernels of maximum length, and the third of ears with kernels of medium length. The latter group was practically intermediate between the short- and long-kerneled ones. Since the degree of indentation is usually correlated with length of kernels, this character was taken as an index by which to classify the various ears. Only ears that were almost smooth or "dimple-dented" were selected for the short-kerneled group, while only ears that were sufficiently indented to have kernels with a chaffy crown or with at least an indication of chaffiness at the crown were used for the rough- or deep-kerneled group. In this latter group the endosperm as a rule was not completely filled. The kernels of the intermediate group were "wrinkle-dented," that is, the indentation was sufficient to cause a wrinkling of the epidermis of the kernel over the indented portion.

The seed for the various groups or types of ears was continuously selected. Smooth ears were selected each season from the progeny of smooth ears, rough ears from the progeny of rough ears, and medium ears from the progeny of medium ears.

In selecting the seed ears, care was taken to secure, if possible, ears that would conform to what is ordinarily considered the standard in seed corn. The ears were well developed, with uniform kernels and in good seed condition.

Determinations of yield were made in plots consisting of six to eight rows. They were planted in triplicate. The four inside rows only of each plot were harvested for yield. The corn was planted thick in 42-inch drill rows and thinned to a uniform stand of one stalk every 21 inches. No effort was made to control cross pollination between corn of the various types, and undoubtedly the usual amount of cross-fertilization took place.

The author presents his detailed results in fourteen very complete tables covering investigations over a period of five years, and concludes:

The popular opinion that smoothness in corn is an indication of deterioration and reduced yielding capacity appears to be erroneous. In the experiments reported the smooth type yielded as well as the medium and rough types on the average and indicated that under adverse conditions it will yield better.

Continuous selection of smooth and rather short kernels for four generations increased the average length of the ears, decreased the circumference, slightly decreased the weight, decreased the number of rows per ear, and decreased the length of the kernel and the percentage of shelled grain.

On the other hand, continuous selection of rough and rather long kernels decreased the average length of the ear and increased the circumference but had no significant effect on the weight of ears, the number of rows per ear, the length of the kernel, or the percentage of grain.

Because of the popular opinion that smoothness of ears is an indication of deterioration, the results of this study are of practical interest. Smooth corn has several advantages over medium or rough. Every corn grower knows that the smooth type is much to be preferred at husking time. This type is not so subject to damage from molds and other fungi following injury to the ears from the corn earworm. The latter factor is often an important one, since moldy corn is dangerous to feed. Rough ears, because of the length of kernel and circumference of the ears, do not dry out as rapidly as the smooth type, and for this reason they are more likely to be low in vitality as a result of freezing. Smooth kernels are less likely to rot when conditions for germination are unfavorable. It would seem, therefore, that the corn grower should not hesitate to select smooth ears. It may be well to select slightly rougher ears than are desired in the progeny, since there appears to be a decided tendency to vary toward the smooth type. It is also well to do this in order to avoid a hard, flinty type of kernel that would be unsatisfactory for feeding.

RESPIRATION OF DORMANT SEEDS

In the July (1921) number of the *Botanical Gazette*, Dr. Hope Sherman of the University of Chicago presents the results of the investigation of the respiration of dormant seeds.

Plant physiologists have long been interested in the physiological processes associated with the development and particularly with the germination of seeds. Much attention has been devoted to those seeds which, when ripe, fail to respond to germination conditions unless subjected to special treatment or permitted to undergo a distinct rest period. Such dormant seeds offer many problems to pique the curiosity of the investigator, and work on individual seeds has given some conception of the environmental factors influencing dormancy as well as of the internal conditions retarding germination and of the chemical changes which take place in after-ripening. Furthermore, dormant seeds often retain their viability for long periods of time. Beale reported that *Amaranthus retroflexus* will remain viable in the ground for thirty years. If such seeds are fully imbibed, their remarkably prolonged viability may be due either to especially large food reserves or to a tremendous reduction of the rate at which such reserves are respired.

The seeds selected for investigation by the author were three on which physiological studies had already been made, but for which respiratory data were lacking, namely, *Amaranthus retroflexus*, *Chenopodium album*, and *Crataegus*, and in addition seeds of the common drupaceous *Rosaceae*. Catalase activity was measured by the volume of oxygen set free from hydrogen peroxide.

The author presents many of her results in tabular form, and says in conclusion:

The respiration determinations were made by means of a respirometer. The respiratory intensity, that is, the mg. CO_2 eliminated per gram imbibed seeds per hour, was determined experimentally for *Amaranthus retroflexus*, *Chenopodium album*, and *Rumex crispus*, as well as for *Crataegus* and certain drupaceous *Rosaceae*.

Catalase activity increases in *Crataegus* under after-ripening and germinating conditions (10 deg. Cent.) up to the forty-second day. The slightly higher value for the 128th day may represent: (1) a continued increase at an extremely slow rate; (2) a limit depending on the amount of dioxogen used (5 cc.); (3) a falling off, as a result of secondary dormancy, of an activity whose maximum occurred at the completion of after-ripening (about the nineteenth day). Respiration reaches a maximum intensity much earlier (sixth to eighth day), and thereafter exhibits a slow and fluctuating decline, at least to the seventy-seventh day.

In *Amaranthus* both catalase activity and respiration are relatively stable. Fluctuations in catalase activity and in respiratory intensity do not occur simultaneously, and may be in opposite directions.

The respiratory quotient and respiratory intensity vary markedly for different seeds, and in the *Rosaceae* for different lots of the same kind of seed under precisely similar experimental conditions.

Stability or variability of the quotient may be of significance as indicative of the possibility of an interplay of several factors on the metabolism.

The arrangement of the respiratory quotients for each seed in a curve showing the percentages of the experiments with each seed giving each value, and in frequency histograms in which are plotted the actual number of experiments in which each quotient value occurred, indicates the tendency of each seed toward a typical respiration.

THE MODE OF ACTION OF COLD BATHS IN INCREASING THE OXIDATIVE PROCESSES

In the *American Journal of Physiology* for July, 1921, Messrs. W. E. Burge and J. M. Leichsenring, of the Physiological Laboratory, University of Illinois, present the results of investigations on the mode of action of low temperatures

and of cold baths in increasing the oxidative processes. Introducing their article, the authors say:

As a result of the work of Lavoisier and of a great number of investigators since his time, it is now known that a fall in the external temperature as well as cold baths increase oxidation in warm-blooded animals and decrease it in cold-blooded animals. The action of cold on the skin of warm-blooded animals produces reflexly an increased innervation of the muscles resulting in movements (shivering) or in the increase in tone. Several observers have shown that unless the lowering of the temperature of the coldness of the bath is sufficient to cause shivering or muscular tension, no increase in oxidation results. Cold-blooded animals, on the other hand, have no heat regulating mechanism such as is found in warm-blooded animals and hence their heat production rises and falls with a rise and fall in external temperature.

The increase in heat production brought about by cold in warm-blooded animals is usually attributed to the additional heat produced by the action of the muscles. Volt believed that the increase in metabolism brought about by cold was due to a reflex stimulation of the muscles resulting in an increase in the inherent power of the muscle cells to metabolize.

The author's experiments were made on 60 warm- and cold-blooded animals. The warm-blooded animals used were dogs and the cold-blooded, turtles. The effect on the blood catalase of keeping these animals in a cold chamber as well as in hot and cold baths, and in baths at different temperatures was tried out.

The cold chamber was constructed large enough to accommodate a dog comfortably. A stream of fresh air was forced through the chamber continuously. Further provision was made for the animal to get fresh air by cutting a small window in the wall of the cold chamber through which the animal could poke its snout. The temperature of this chamber could be kept fairly constant over a period of several hours. Catalase determinations were made of the blood of the jugular before as well as at intervals after the dogs were placed in the chamber. The determinations were made by adding 1 cc. of the jugular blood to 50 cc. of neutral hydrogen peroxide in a bottle and the amount of oxygen liberated in 10 minutes was taken as a measure of the catalase content of the blood. The normal catalase content of the blood was established by making determinations on two or three successive days previous to performing the experiment.

The cold-blooded animals used were turtles (*Pseudemys concinna*). The blood used was taken from the aortic arches through a hole 2 cm. in diameter made in the plastron just over the heart. This hole was kept closed by a cork.

Various experiments are described and their results given by plotting curves.

In conclusion the author finds that low temperatures and cold baths produce an increase in the blood catalase of warm-blooded animals and a decrease in cold-blooded animals, in keeping with the fact that the cold increases oxidation in warm-blooded animals and decreases it in cold-blooded animals. An increase in the external temperature increases the blood catalase in cold-blooded animals in keeping with the fact that it increases the oxidative processes.

The stimulating effect of low temperatures on catalase production in warm-blooded animals decreases with a rise in temperature, disappearing at room temperature (22 deg. Cent.) in keeping with the fact that the stimulating effect of cold on metabolism decreases with a rise in temperature. Baths at 35 deg. Cent. produce no increase in oxidation in warm-blooded animals and it is shown in this paper that such baths do not increase catalase.

The increase in oxidation in warm-blooded animals on exposure to cold is attributed to an increase in catalase, and the decrease in oxidation in cold-blooded animals on exposure to cold, to a decrease in catalase. The increase in oxidation in cold-blooded animals occurring with a rise in external temperature is attributed to an increase in catalase.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

HEAT TREATMENT STUDIES

A report of tests of heat-treated carbon-molybdenum and chromium-molybdenum steels has been completed and will be presented at the September Convention of the American Society for Steel Treating.

I. STEEL CONTAINING 0.20 PER CENT CARBON AND 1 PER CENT MOLYBDENUM

1. For each maximum temperature of heating there is a critical rate of cooling which will lower Ar_1. The higher the initial temperature the slower is the rate of cooling required to produce the lowered transformation but by whatever combination this is produced the position of the "low point" is fixed within a narrow temperature range about 525 deg. Cent. (975 deg. Fahr.). Its suppression can readily be brought about, however, by increasing the rate of cooling.

2. A high temperature transformation is observed slightly above and almost merging with Ar_3 when the steel is cooled from temperatures at or above 960 deg. Cent. (1760 deg. Fahr.) at a rate of temperature change approximating 0.15 deg. Cent. (0.27 deg. Fahr.) per second but is not observed when cooling at a much faster rate.

3. Ar_2 is fixed at about 760 deg. Cent. (1400 deg. Fahr.) independent of the maximum temperature of heating or rate at which the steel is cooled.

4. The most suitable temperature from which to harden the steel is in the neighborhood of 910 deg. Cent. (1670 deg. Fahr.). Free ferrite is found after quenching from 830 deg. Cent. (1525 deg. Fahr.) but the observed changes in mechanical properties with rise in quenching temperature within this range cannot be explained by known changes in carbon or iron, by differences in the rate at which the steel passes through the critical ranges resulting from changes in initial temperature of cooling, by unsatisfactory hardening or by the lowered Ar_1 transformation (except as related to a molybdenum change), for they are opposite to the changes found in plain carbon steel under similar conditions of treatment.

5. For the production of definite tensile strength, water quenching is to be preferred on account of the higher proportional limit, ductility, and impact values obtained and conversely better tensile properties are obtained for a given impact resistance.

6. Raising the quenching temperature from 910 deg. Cent. (1670 deg. Fahr.) to 980 deg. Cent. (1795 deg. Fahr.) does not materially alter the mechanical properties of the steel when subsequently tempered at the relatively high temperature 540 deg. Cent. (1000 deg. Fahr.).

II. STEEL CONTAINING 0.27 PER CENT CARBON, 0.9 PER CENT CHROMIUM AND 0.5 PER CENT MOLYBDENUM

7. The Ar_1 transformation is first split and lowered when cooling from 960 to 1000 deg. Cent. (1760 to 1830 deg. Fahr.)

at about 0.15 deg. Cent. (0.27 deg. Fahr.) per second, the "low" point being observed at about 480 deg. Cent. (895 deg. Fahr.). In water quenching from the highest temperature, a lower hardness is obtained than when similarly cooling from 960 deg. Cent. (1760 deg. Fahr.). In this respect the chromium-molybdenum steel behaves similarly to steel containing 0.20 per cent carbon and 1 per cent molybdenum except that the observed changes are produced from higher temperatures.

8. In normalizing the chromium-molybdenum steel, a low limit of proportionality and impact resistance are obtained when using temperatures between about 780 to 845 deg. Cent. (1450 to 1550 deg. Fahr.).

9. The fact that no material changes in tensile or impact properties are produced by oil quenching the chromium-molybdenum steel from a wide range of temperatures when subsequently tempered at 540 deg. Cent. (1000 deg. Fahr.) has been confirmed. To produce high impact values in the hardened steel, a tempering temperature in the neighborhood of 650 deg. Cent. (1200 deg. Fahr.) is required.

EXPERIMENTAL PAPER MILL BEING SENT TO SIAM

Siam will soon have an experimental paper mill made in America with equipment recommended by the Bureau of Standards. This paper-making plant, which, although not primarily intended for commercial purposes, will furnish the writing and printing paper for the Siamese army, is now being carried across the ocean to this Asiatic country.

The mill is complete in every detail and spare parts and supplies are included in the shipment. It is patterned after the experimental mill located at the Bureau of Standards which has been in operation since 1913, and was made by representative manufacturers of paper mill machinery in this country. The mill being sent to Siam is about 50 per cent larger than the one at the Bureau, and is capable of producing 1200 pounds of paper daily.

Siam is interested in paper-making because of the possibilities of turning some of her grasses, weeds, and other fibrous plant products into paper. The paper mill will be used in making researches which will aid in the development of a Siamese paper industry.

Bureau of Standards' tests have shown that rice straw, banana tree stems, and lalang grass will make paper. These materials were sent to the Bureau from Siam and were made into paper in the mill. Siamese experiments will be made to develop the best methods of using jawa weed and other plants of that country as well as waste paper.

America is also sending to Siam with the mill a trained paper maker and engineer who will superintend the erection and operation of the mill.

The interest of the former Siamese Minister, Probha Karavongse, in the experimental mill located at this Bureau led to the purchase of the paper-making machine which will be erected at Bangkok, Siam, under the supervision of the Royal Survey Department of the Siamese army. Siamese officials saw the possibilities of the paper industry in their country and their government asked the American Government, through the State Department and the Department of Commerce, to supervise the design and purchase of the experimental machine.

The paper mill consists essentially of a 44-inch Fourdrinier paper machine; two 300-pound wood-tube beaters; a small Jordan engine; a 600-pound rotary boiler; a cylinder duster; screen; sheet cutter; suitable pumps, shafting, pulleys, and motors; a bleach plant; necessary electrical fittings, and plumbing, belting, and spare parts.

COLORLESS WATERPROOFING MATERIALS

A preliminary report of exposure tests on specimens of stone treated with these materials is being issued and will be available for distribution during September. This report shows the effects of 6 months' exposure to the weather on the waterproofing value of 19 different treatments. It also shows the effect of the appearance when applied to light colored stones.

Copies of this report may be secured by persons interested in this subject by addressing the Bureau of Standards, Washington, D. C.

FOREIGN SPECIFICATIONS FOR PORTLAND CEMENT

The Bureau has recently completed a summary of the Portland cement specifications of various countries. This included not only the principal requirements but also many of the details of methods of tests, which details are frequently of great importance when considering the specifications of some of the countries. However, for ready reference, the principal physical and chemical requirements have been assembled in a single chart 16 x 22 inches, and copies may be obtained by persons interested by addressing the Bureau of Standards, Washington, D. C.

TENSILE PROPERTIES OF STEELS AT HIGH TEMPERATURES

The report of tests of alloy steels at elevated temperatures completed last month has been accepted for Bureau and outside publication under the title "Tensile Properties of Some Structural Alloy Steels at High Temperatures" and will be presented at the September Convention of the American Society for Steel Treating.

Four steels containing about 0.40 per cent carbon were tested at various temperatures between 20 and 550 deg. Cent. The type compositions follow: (a) Plain carbon steel; (b) 3½ per cent nickel steel; (c) steel containing 3 per cent nickel and 1 per cent chromium; (d) steel containing 1 per cent chromium and 0.2 per cent vanadium.

Of the four steels tested it appears that the two alloys containing chromium show greater resistance to weakening by increase in temperature to about 550 deg. Cent. than either the plain carbon or 3½ per cent nickel steels, and at this high temperature the chromium vanadium steel is to be preferred from the standpoint of high tensile strength and limit of proportionality.

The carbon and 3½ per cent nickel steels behave alike with rise in temperature above that of the room and at about 550 deg. Cent. the addition of 3½ per cent of nickel appears to have little or no effect on the tensile properties of the carbon steel.

Reference is made in the report to the type of fractures obtained in testing steels at various temperatures and typical microphotographs are included.

CALCIUM SILICIDE

The use of calcium silicide was recently discussed by *The Iron Monger* as a deoxidizer particularly in steel making in electric furnaces. The compound is now being made on a commercial scale in France and is somewhat similar to ferro silicon. When added to the molten metal the compound dissociates so that the elements combine first with the oxygen present in the bath and then recombine as calcium silicate which appears in the slag. The reaction is so vigorous that sufficient energy is liberated when the silicide decomposes to raise the temperature of the bath of metal. The compound, therefore is valuable in assisting to bring cold baths to the proper pouring temperature. Under the conditions obtaining in the electric furnace the system has also been found to act as a desulphurizer. No harmful inclusions in the metal are left behind and great soundness is claimed for the castings. Calcium silicide is usually added to the bath in small quantities in paper bags which are completely buried in the ladle of metal. From 10 to 20 ounces of the compound per ton of metal are used where the carbon is not more than 0.3 per cent. Where the carbon is above that figure about 30 ounces per ton have been found necessary.

Calcium silicide is hard, bright, and metallic and is easily reduced to powder.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME RECENT FOREIGN POWER PLANTS

The *Elektrotechnik und Maschinenbau* for June 5 and 12, 1921, describes the Zillingsdorf power plant located at a distance of about 80 km. from Vienna in a district rich in lignite deposits. The caloric heat of this lignite varies from 2034 to 3200 metric heat units per kilogram. Most of this lignite appears on the surface and is mined by means of dredges. The present equipment of the power plant consists of eight high power steam boilers, each having 500 sq. m. of heating surface; two 8000-hp. and two 12,000-hp. turbo generators giving three-phase energy of about 5000 to 5500 volts. The boilers were equipped with a firing system suitable for burning this low-grade brown coal; very large grates and a deep fire and an automatic staircase-grate were necessary. The plant, according to tests, has a boiler efficiency of 77.1 per cent.

The 38-km. transmission line consists of two 70,000-volt, three-phase lines of 50 sq. mm. copper strands. These are supported on steel towers spaced 150 m. apart in the open and 60 m. near inhabited places. A steel cable fastened to the top of the poles acts as a lightning arrester. Four-disk and five-disk insulator chains are used. Inductive interference is avoided by having the lines transposed twelve times; the telephone wires are carried on separate poles, following a different route. During the year of 1920 energy amounting to over 60,000,000 kw-hr. was transmitted to Vienna, which helped very materially to overcome the coal shortage.

Another interesting plant is that of the Tata Hydroelectric Supply Company in India. A detailed description of it will be found in the *Siemens Zeitschrift* for April, 1921 and an abstract in *Electrical World* for August 27, 1921. To utilize the large amount of annual precipitation during the wet season three large artificial lakes have been made on the west coast of India about 520 m. above the sea level. A total of 300,000,000 cu. m. of water may be accumulated in these lakes during a period of three to three and one-half months. From the water-collecting tower two riveted steel pipe lines of 2 m. diameter each lead down 2700 m., splitting up from this point into five lines of 0.8 m. each. The entire right-of-way for the pipes has been blasted out of the solid rock of the slope. At present five main turbines of the Pelton bucket-wheel type are installed, each rated at 13,750 hp. and operating under a pressure of 50 atmospheres and 300 r.p.m. Each turbine is coupled to a 10,000 kva., 50-cycle generator delivering 6000-v. three-phase current. The power house has room for three more units. The high average air temperature of 45° C. called for great liberality in designing the generators. In fact, the machines as built would be sufficient for 16,000 kva. in northern climate. In spite of the climate the generators show an efficiency of 95.8 per cent.

AIR-INSULATED TRANSFORMERS FOR VERY HIGH VOLTAGE

In designing testing transformers for very high voltage—200 kv. and more—it is considered a matter of course to choose the oil-insulated type. Although oil makes it possible to cut down the necessary distance between the coils to one-third of the necessary distance in air, it has been proved that after the first brush discharge under oil the high initial dielectric strength of the oil is rapidly decreased along the path of discharge, leading soon to a breakdown. The author points out further that a reliable lead construction through the metallic cover of the oil tank of the transformer is almost impossible for more than about 300 kv. A Swiss firm (Haefely) investigated the possibilities of air-insulated dry-type testing transformers and developed a new model of this type, a 200-kva., 300-kv. testing transformer, which gives good results in daily service in the firm's testing laboratory. The necessary striking and creeping distances have been obtained by properly dimensioned air spaces, the use of paper cylinders and a careful distribution of the electrostatic stress by means of metallic shields over and near the end turns. In spite of the large outfit and very high potential (300 kv.) the finished transformer weighs only 4½ tons, or 70 per cent less than an equivalent oil-type machine. Even with a 25 per cent overvoltage it is claimed no discharges are visible if the machine is fully excited in the dark. The winding of the transformer is of the concentric style, and the high voltage is grounded in the middle (at the end of each of the two coil stacks). By using one or more additional transformers in series with the main transformer as much as 500 kv. against ground may be obtained safely. Such a tandem group is in use at the testing laboratories in Zurich for 400 kv. The author is of the opinion that the design of high-voltage power transformers should not meet with great difficulties.—Dr. W. Hess, *Bulletin de la Association Swisse des Electriciens*, May, 1921. *Electrical World*, August 27, 1921.

ELECTRICAL RESISTANCE AND INSTRUMENTS BASED ON THE TEMPERATURE-VARIATION OF RESISTANCE

A discussion on this subject was recently held by the Physical Society of London, which discussion was reported at considerable length in their *Proceedings* for April 15, 1921. It discloses a great number of scientific measuring devices based on the variation of electrical resistance and clearly shows the ever-increasing field of their usefulness in science and industry.

The discussion was opened by Prof. Richard Glazebrook who presented a paper in which he gave a historical account of the absolute determination of the unit of electrical resistance. This was followed by a paper by F. E. Smith who made the following two proposals: (a) All resistances should be expressed in ohms (10^9 cm./sec.), without qualification, such as legal, international, etc. The ampere and volt should be similarly treated. (b) Resistance should be more often measured in terms of the C.G.S. units by means of the rotating coil method.

Several authors then presented papers reviewing the recent progress made in resistance thermometry. Prof. H. L. Callendar briefly reviewed the theory and uses of calorimetric thermometers, compound thermometers for linear scale, compensation of thermometers for conduction along the leads, compensated bolometer and the radiobalance. Mr. C. R. Darling reviewed the early work on the resistance pyrometer, Mr. C. Jakeman described the resistance thermometers for steam temperatures. These are used in connection with experiments upon the properties of steam under pressure; they are platinum resistance thermometers with envelopes of steel tube arranged so that the metal envelope could be screwed into a special fitting in the steam pipe. Mr. Edgar A. Griffith gave a detailed description of an electric transmitting radiator thermometer. It is of interest as it is commonly supposed that resistance thermometers find no application on the modern airplane. The outfit described was captured during the war and formed part of the equipment of a bombing machine. It was used for measuring the temperature of the water in the engine

radiators, and two pyrometers were connected to one indicator fixed on the instrument board.

The *hot wire microphone* was discussed by Major W. S. Tucker. Details of this instrument were given in a paper on "The Selective Hot-wire Microphone," read before the Royal Society on January 20 of this year. In his paper Major Tucker primarily discusses experiments illustrating the function of convection currents in determining the sensitivity of the hot-wire microphone.

Considerable attention was also given to hot wire anemometry. The latest development along this line was given by J. S. G. Thomas in a paper entitled "Directional Hot-wire Anemometer." According to the author, the laws of convection of heat from fine heated wires are such as to indicate the hot-wire type of anemometer as the proper type of instrument for the precise measurement of the velocity of a slow moving stream of fluid. The usual type of the hot-wire instrument, as devised by King and Morris, is not suitable in such a case, owing to the disturbing influence upon the convection current arising from the heated wire exposed to the cooling action of the stream. In the directional type of instrument, two fine platinum wires are mounted parallel, and one behind the other in close juxtaposition, transversely to the direction of flow of the gas in the pipe or channel. The wires are inserted in a Wheatstone bridge in the usual manner, and the indications of the instrument enable both the magnitude and direction of a slow-moving stream of fluid to be readily ascertained. For further details the author refers to a number of papers previously published by him. Along the same line was the paper presented by Alfred H. Davis and entitled "An Instrument for Use in Measuring Convected Heat." The apparatus consists essentially of a Wheatstone's net and is a null instrument.

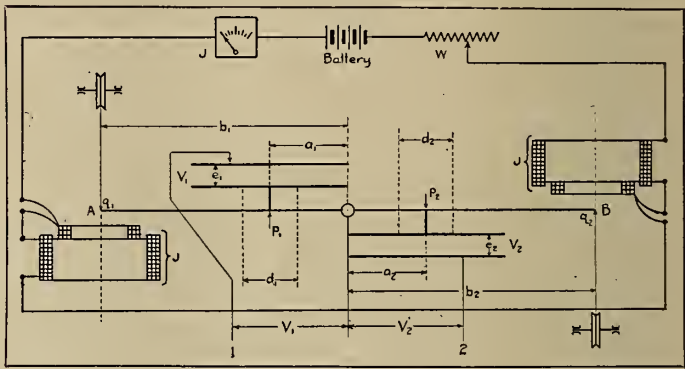
The *catharometer* and its many applications to the measurement of the composition of industrial gases were discussed by Messrs. G. A. Shakespear and H. A. Daynes. A brief description of it will also be found in an earlier issue of the Scientific American Monthly. The *caleometer* is an instrument designed by Prof. Leonard Hill; it measures the heat loss of a wire coil maintained at a constant temperature. It enables the meteorologist or hygienist to record daily variations of the rate of cooling of a surface at body temperature produced by atmospheric conditions. The records taken out of doors thus obtained throw light on the causation of those feelings which lead us to define the weather as pleasant, unpleasant, bracing, muggy, etc. Records taken indoors enable one to measure the cooling power of the atmosphere on a surface at body temperature and guide one to the securing of adequate ventilation.

Finally, Edgar A. Griffith described the liquid depth gage. It is based on the well-known fact that the cooling power of a liquid is vastly greater than that of a gas. It consists essentially of a thin wire of platinum electrically heated to a temperature excess of about 20 degrees above the surrounding air. The wire is insulated and suitably protected by a tube projecting to the full depth of the tank. The portion of the wire immersed in the liquid is cooled down to practically the same temperature as the liquid, while the part above the surface is at the excess temperature. It is evident that the average temperature and hence the resistance of the wire, will depend upon its depth of immersion in the liquid. The changes in resistance are then measured by a Wheatstone bridge arrangement.

AN ABSOLUTE VOLTMETER FOR 250,000 VOLTS EFFECTIVE

The instrument described is an absolute electrostatic voltmeter for use in calibrating high-pressure voltmeters. Nitrogen at 12 atmospheres is used for insulation, its breakdown pressure at 10 atmospheres being 240 kv. per cm. (according to Petersen), *i.e.*, more than twice that of the best transformer oil. Other advantages of nitrogen in this application are: (1) The insulation is not deteriorated by a flash-over, but is improved. (2) The dielectric constant is nearly 1.0. (3) There being no oxygen present, no ozone is formed, and there is no burning at the point of sparking. (4) Oil would damp the moving system excessively.

The arrangement employed is shown diagrammatically in the figure. The instrument consists of a double voltage-current balance, the beam AOB of which is pivoted at O. The balance is symmetrical about O, components to the left and right being distinguished by suffixes 1, 2, respectively. At distances A_1 A_2 from O there are fixed to the beam pressure plates of diameters d_1 d_2. These are surrounded by guard rings which lie in the same plane as the movable voltage plates and are connected electrically therewith. Fixed voltage plates are mounted at a distance e_1 e_2 from the movable plates. The potential difference V_1 V_2 is applied between the fixed and movable plates. At distances b_1 b_2 from O the beam carries movable current coils which dip into larger fixed coils as shown. The four current coils are traversed in series by the same current J. The torque applied to the beam by the movable voltage plates is proportional to the square of the applied voltage. Similarly the torque applied by the current coils is proportional to J^2, hence when the beam is balanced V is proportional to the compensation current J. A moving coil ammeter measuring J may be calibrated to read directly in volts, the instrument giving the effective value of applied voltage independent of frequency and wave form.



VOLT METER FOR HIGH VOLTAGE

As constructed, the instrument consists of a thick-walled bronze vessel in the form of a rectangular chamber with large cylindrical extensions on opposite sides. The high-tension connections are carried through corrugated cylindrical insulators in the tubular extensions to the balance, which is mounted in the rectangular chamber across the length of the instrument. The casing is tested to an internal pressure of 20 atmospheres. The leading insulators are hollow and are so perforated that they are exposed internally as well as externally to the compressed gas. The spacing between the leading-in bolt and the flange holding the insulator in the casing is such that flash-over would occur at this point rather than from the delicate voltage plate of the instrument. Equilibrum of the balance is determined by observing a mirror in the instrument through a telescope.

It is impossible to determine the accuracy of the instrument by direct comparison with a standard instrument. The author, therefore, considers individually the possible sources of error and their magnitude. The sources of errors are as follows: (1) Stray electric and magnetic fields. (2) Temperature effects and mechanical expansion of the instrument chamber. (3) Inequality of corresponding right and left dimensions. (4) Errors in determination of the individual quantities and dimensions in the equation or law of the instrument. The author investigates each of these groups of possible errors in considerable detail. The highest possible error due to errors in the values accepted for the dielectric constant of nitrogen, the balance weight, and the linear dimensions of the instrument is considered to be ± 0.187 per cent. Allowing also for errors in current measurement and for

errors in balancing, the total error is from 0.6 to 1.0 per cent at 50 or 100 kilovolts (parallel or series connection) and about 0.35 per cent at 150 or 300 kilovolts. The capacity of the instrument in series connection is about 10 cm.; hence, high-frequency measurements may be made. The instrument has been used up to 300 kv., and the author considers that similar instruments could be built for much higher voltages.—A. Palm. Abstracted in *Science Abstracts*, Section B, May, 1921, from *Zeits. Techn. Physik*.

ELECTRIFICATION PROGRAM OF CZECHOSLOVAKIA

Prof. Fernando Pietsch gives in *Electrical World* for August 20, 1921, a detailed account of the present and planned developments in the new Czechoslovak Republic.

As far as a geological survey could ascertain the republic has within its boundaries total resources of anthracite, bituminous and lower grade coal amounting to about 140,000,000,000 tons. According to official statistics for the year 1920, the coal production was: Anthracite, 5,565,000 tons; coke, 700,000 tons, briquets, 722,000 tons; and bituminous coal, 9,800,000 tons.

The maximum output of the hydroelectric power plants, either already available or soon to be developed, is as follows: In Bohemia, 355,000 kw.; in Slovakia, 200,000 kw.; and in Moravia, 59,000 kw.; this gives a total of over 600,000 kw. for the entire republic. Statistics for 1919 showed 390 power plants in the republic, of which there were six rated at more than 10,000 kw., three from 5000 to 10,000 kw., and twenty-eight from 1000 kw. to 5000 kw.

The new electrification law which passed on July 22, 1919, provides for a general and systematic power supply of the entire republic. A first appropriation of 75,000,000 crowns has been made and will be used for the enlargement of hydroelectric plants and for the assistance of such associations as will be a part of the new system. Financial participation of counties and joint stock companies in this public service system has been limited to a maximum of 25 per cent. All plants which will participate in the general electrification plan have been classified as public utilities and will enjoy certain rights.

Of great importance is the establishment of a consulting board for the entire system, consisting of representatives of industry, agriculture, science, labor and consumers of energy. All plans for new developments have to be presented to this board for approval. This board has established a number of standards for the systematic carrying out of the work, the most important of which are: Steam power plants should be erected only on a large scale and if possible near mines. Hydroelectric plants should be operated to maximum economy along the whole river and should be built with a view to co-operation with other nearby plants. All transmission lines should be so built as to form a uniform network. All energy generated should be three-phase at 50 cycles. Railway power stations and enterprises which can prove that such energy will not fill their requirements are excepted. For the standard feeder voltage of 22,000 volts has been decided upon, except for nearby power supply for which the direct generator voltage is sufficient. For the standard trunk-line voltage of 100,000 volts has been chosen, with the permission to use temporarily 50,000 volts. The consumers' voltage should be 220-380 volts. For private enterprises 500 volts with grounded neutral is permissible. In direct-current distribution systems 440 volts with grounded neutral should be provided. As standard generator voltage 6000 volts has been established.

The goal of the whole program is to supply all needed electrical and mechanical energy from this systematized network into which nine large steam power plants will feed. Besides these all hydroelectric plants which operate by means of water storage are to be tied in and to cover all peak loads in order to save coal. Assuming this hydroelectric energy to amount to 500,000 kw., a yearly saving of about 6,000,000 tons of coal will result. For all new steam power plants gasification of coal on a large scale is recommended, so as to obtain all the valuable by-products such as tar, ammonia, etc.

The cost of the new steam power stations and lines is estimated at about 1,500,000,000 crowns. These stations and the network should be completed in twenty years, while about fifty years is allowed for the completion of the hydroelectric developments.

The use of electrical energy could be increased very materially by electrifying the principal railroads, but present conditions are not promising for this, and it is found far more profitable to sell the energy for industrial purposes. The railroad department is, however, investigating a main road electrification within 50 km. of Prague which would relieve the present very congested conditions.

ELECTRICAL EQUIPMENT OF GYRO STABILIZERS FOR SHIPS

The *Electric Journal* for August, 1921, has several papers giving in detail the design and installation of the electrically equipped gyroscopic stabilizer on the steam yacht "Lyndonia."

Alexander E. Schein discusses the laws and nature of the rolling of a ship; he then reviews the development of the gyro stabilizer. The passive type was invented by Dr. Schlick. It was called "passive" because it was not effective until the roll of the ship was large enough to "precess" the gyro. It, therefore, could not decrease all of the roll due to its sluggishness. The active type stabilizer was invented by Mr. Elmer A. Sperry of New York and was a very great improvement over the passive type in that it introduced ingenious controls which enable the stabilizer to become operative a fraction of a second after roll started, and the result is that roll can be decreased to very small angles. The author then proceeds with briefly reviewing the theory of the gyroscope and of the methods of design of the "Lyndonia" equipment.

The details of the actual construction are given in a paper by Mr. W. T. Manning, while T. P. Kirkpatrick and H. C. Coleman present the details of the electrical equipment. The principal operations of stabilizing a vessel are controlled by two motors, the spinning motor and the precession motor. The spinning motor, as its name implies, keeps the rotor spinning about its axis, which is normally vertical. The precession motor, operating through a worm gear, precesses the stabilizer at intervals corresponding to those of the waves. The combination of these two rotation sets up a gyroscopic couple at right angles to both of them. This couple, transmitted through the gudgeon bearings to the ship structure, counteracts the efforts of the waves to make the ship roll. The complete electrical equipment required by the stabilizer consists of the following. (1) Control gyro; (2) precession motor; (3) generator to supply power to precession motor; (4) magnetic brakes for precession system; (5) motor-driven vacuum pump; (6) control panels; (7) spinning motor; (8) generator to supply power to spinning motor. In this paper special attention is given to the precession system and the spinning motor.

Of special interest is an editorial in the same issue of *Electric Journal* written by E. A. Sperry. According to the inventor of the stabilizer the popular conception of stabilizing a great transatlantic liner is entirely erroneous. There is inevitably pictured a titanic contest of the great rolling mass of the ship in the grip of something potentially as gigantic, struggling to subdue part of its motion. This conception also affords an explanation of the enormous stresses that are supposed to be involved in the process. Now, this is not at all true; it is much easier and simpler. We do not reduce the roll, we suppress it utterly by dealing only with beginnings. All rolling of ships is a gradual accumulation of individual wave increments. The slight extent to which any single wave rolls the ship is now well understood, and all that is required is a comparatively small gyroscope that is capable of completely quenching this single increment.

A little gyro feeler or "control gyro" detects the incipient roll at its beginning and also shows its direction. This is the

crux of the whole cycle; the rest is easy. Through a relay and motor the large gyro is artificially precessed and delivers stresses of opposite sign to the ship.

To anticipate, however, one must apply the counter moments simultaneously to their being received from the sea. This would be impossible were it not for the slow period of the ship itself, which gives an abundance of time to get precession under way and deliver the counter stresses within the half period, continuing until the ship has actually been given a counter incipient roll, whereupon the electric contact in the control gyro is broken, indicating that that particular wave has been fully countered, meanwhile the ship, having received equal stresses of opposite sign, never starts to roll. This process involves not only a relatively small apparatus, but entails merely a trifling stress in the hull, that due to a single wave increment only, involving stresses of from one-sixth to one-tenth those present in a rolling ship.

The disappearance of roll is accompanied by a most satisfactory suppression of pitch. On most headings more than sixty per cent of the pitch disappears with the roll. An astonishing difference in headway also exists between a stabilized and unstabilized ship, repeated records showing between ten and twelve per cent. The importance of such a substantial gain cannot be neglected. It has been found through work done last autumn by Commander McEntee at the Naval Basin and other correlated results since obtained that the stabilizer will make a saving of upward of thirty per cent in heavy weather.

The gyro stabilizer seems to be fitted by nature to deal with large ships. The stabilizing strength varies as the sixth power of the size. For example, a gyro twice the size of another would have to rotate at only one-half the speed of the smaller one to stabilize a ship 64 times the size, *i.e.*, 64 times the total periodic mass can be handled at a cost and weight of less than nine times.

The gyro causes pounds easily to deliver tons of useful torque. Not only does it relieve the ship of all major stresses and increase its life, but it imparts marvelous comfort to the passenger carrier. Stabilizing also prevents the serious depletion of cattle and horses in live stock ships. Through a variety of other important economies to which it directly contributes, it constitutes a definite dividend payer of large magnitude, paying for itself in a comparatively few trips.

MAGNETIC PROPERTIES OF COMPRESSED POWDERED IRON

The development of a successful method of compressing insulated grains of iron to produce a material magnetically and electrically suited for use in the telephone plant has had a determining effect upon recent progress in methods of loading and compositing telephone lines as well as upon the introduction of carrier systems of multiple telephony. The most important use of this material is in the construction of cores of the loading coils which are introduced at regular intervals to increase the inductance of a telephone circuit. It is also used in the cores of inductance elements in filters for carrying current systems and in those of reactance coils and transformers for radio telephone circuits. The requirements which are to be met involve a core material which should have a constant permeability, a small hysteresis loss and a small eddy current loss within the range of magnitizing forces and frequencies which are met in a telephonic operation.

These requirements were met successfully in the early development of loading coils by the use of hard iron, preferably in wire form. It was found necessary to have this wire drawn to a diameter of 0.004 in, and, in addition, to insulate the separate convolutions of the contiguously-wound core. Cores constructed in the above manner were used for a number of years. With the introduction of repeaters, and especially on composited and phantomed circuits, the requirements as to stability and constancy in the physical characteristics and operation of loading become more severe. To meet these conditions it was found necessary to introduce air gaps at right angles to flux path in the core of the loading coil.

The production of this hard-drawn wire requires the use of diamond dies, and these were imported from Europe. Early during the war importation became impossible, and our supply of hard-drawn wire was thus seriously curtailed. Fortunately the development of the powdered-iron cores while not completed had reached the stage when the material could be quickly put into commercial production to meet the demand for core material.

The authors then give a historical review of the efforts made by previous experimenters to develop such a material; this is followed by a detailed account of their own experimental work and of methods and results of tests of the electrical and magnetic properties of the material developed.

Powdered-iron cores are now manufactured by the Western Electric Company at Hawthorne, Ill. The present equipment has a capacity of 25,000 pounds of iron powder per week. Satisfactory iron is obtained by electrolysis of a solution containing ferrous sulfate and chloride and ammonium sulfate, using anodes of mild steel and cathodes of polished sheet steel. In each tank there are sixteen cathodes and a corresponding number of anodes. An electric crane lifts only the alternate cathodes at a time, partly for convenience in washing and handling, and so that the operating conditions in the tank will be less violently altered than if all the electrodes must be started fresh at once. After being stripped from the cathode the electrolytic iron is ground in a Hardinge conical-ball mill. These mills operate with automatic feeders and deliver their output to rotating brass sieves having 80 meshes to the linear inch. The portion of the iron which is to be annealed is treated in cast-iron pots which hold about one hundred pounds each. During the process of annealing the powdered iron is sintered to a fairly coherent mass. In order to reduce the iron to its original mesh the annealed product is passed through a rotary rock crusher and a disk grinder. It is then sifted again by means of the jagger tables.

The sifted powder is then rolled with flaked zinc in worm-driven drums and shellacked and dried in similar drums. The latter are provided with steam ejectors for drawing a current of air through the shellacked mass as it dries and is slowly tumbled. For compressing the finished powder into cores there is used a short-stroke, quick-acting hydraulic press, producing a pressure of about 200,000 pounds per square inch of surface area of the finished ring. At times this press has been operated to give as high as 300,000 pounds per square inch. Severe requirements have, therefore, been imposed upon the design and construction of the steel die in which the matrial is compressed. The dies at present in use have been specially designed and treated, and their perfection is such that several thousand rings may be pressed from a single die before it must be discarded because of wear, cracks or distortion. The cores are constructed from the rings obtained.

This process has been in operation for about five years and has produced an enormous number of cores which are today widely. distributed over the United States in the telephone plants of the Bell system.—Buckner Speed and G. W. Elmen, *Journal of the American Institute of Electrical Engineers*, July, 1921, pp. 596-609.

CHARGING FOR IDLE CURRENT

The framing of a tariff to encourage high power-factor on consumers' circuits by charging at a higher rate for reactive than for active current, is discussed by C. G. Carrothers in *Electrical Review* of April 1, 1921. This can either be done by employing two separate meters, one arranged to read in k.w.h. and the other in k.v.h. sin ϕ h., or by a single modified meter such as that of Prof. R. Arno which will give the required result with one reading. The author, however, prefers a two-meter arrangement as being more intelligible to the consumer, and describes an alternative system in which the two meters read k.v.a. cos ϕ h. and k.v.a. sin ϕ h. respectively.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

"ANTHRACOAL"

For the purpose of encouraging discussion at its September meeting the American Institute of Mining and Metallurgical Engineers prepublish abstracts of certain papers. One of these is on "Anthracoal: A New Domestic and Metallurgical Fuel," by Donald Markle, and is reprinted here from *Mining and Metallurgy* for August, 1921:

Anthracoal is a mixture of small particles of anthracite coal and a matrix of practically pure carbon, formed from the distillation of coal-tar pitch or other suitable bitumen. It is a hard, dense, homogeneous mass, with a silvery luster and, in color, varies from silvery to grayish black. When pushed from the oven it develops only partly the fingerlike structure of coke; but, unlike coke, it has a tendency to remain in blocky masses. When struck with a hammer or passed through crushing rolls, it breaks with an irregular fracture, similar to anthracite, but with very little fines. Due to its density, anthracite is harder, tougher, and stronger than coke.

Anthracoal can be made in a coke oven upon the same large scale as bituminous coke and can be produced with little greater expense; therefore it should prove a tremendous factor in utilizing the anthracite culm now going to waste.

The percentage of pitch used varies somewhat with the pitch, the character of the culm, and the method of mixing and grinding the material. In the tests at Syracuse, two grades of pitch were used, one with a melting point of 265° F. and one 280° F.; both worked well. The amount of pitch used varied between 14.8 and 25 per cent, due to the method of proportioning. Ovens that contained 15 per cent pitch and 85 per cent culm, by weight, gave an excellent anthracoal and pushed readily. Ovens that contained 25 per cent pitch and 75 per cent culm also gave an excellent anthracoal but more of a thick carbon scale was noted in the ovens than when the mixture contained less pitch; also, the anthracoal was more porous than that made from the 15 and 17 per cent mixtures. After many tests, both in the coke ovens and in the laboratory, it was found that between 16 and 17 per cent produced the best anthracoal with minimum fines and scale. Using below 16 per cent pitch, the anthracoal showed signs of attrition and not holding together, while above 17 per cent the surplus pitch flowed to the sides of the retort and produced a carbon scale that made a great deal of fines when pushed on to the dock.

A direct comparison between chestnut size of anthracoal and chestnut size of anthracite coal was made by an eight-day test of each in a kitchen range. The range performed the same service in each test, cooking three meals a day, heating water in the boiler, and, in fact, doing exactly the same work in each case. Observations were made as to amount of fuel fired each day, the amount of ashes produced, and the position of the drafts during each run. The fire was started with wood at the beginning of each test and allowed to burn completely out at the end of the eight days. The fire was dampened at night and between meals with equal ease with the anthracoal and anthracite.

The total fuel consumed in each eight-day test was 288.5 lb. anthracoal and 346.52 lb. of anthracite, or 20.1 per cent more anthracite than anthracoal. As exactly the same service was obtained from each fuel, the results show that in this range the chestnut anthracite was 20 per cent less efficient than the anthracoal of the same size.

The evidence and data submitted thus far appear to point to a plant of regenerative non-recovery ovens; that is, a plant where the gas is brought directly from the charge into the flues and regenerative apparatus of the oven instead of passing through cooling coils and other apparatus for abstracting the by-products before it is burned.

The reasons for doing this are as follows:

1. If the gas is cooled first the sensible heat will be lost.
2. Removal of the by-products will lessen the heating value of the gas.
3. The by-products in the anthracoal gas are about one-third to one-half those in the bituminous gas, so that it is doubtful, with the uncertain and changing market, whether the recovery of the by-products would be worth the expense of the by-product apparatus which, in cost, represents one-half the cost of the ovens.
4. A non-recovery oven of the regenerative type will burn the gas direct, have the benefit of the sensible heat in the gas as it comes off the charge, and also have the additional heat value of the by-products which are not removed.
5. The ovens should prove to be self-sustaining and have ample gas for an exceptionally hot retort and quick cooking in the non-recovery type.
6. A non-recovery type oven operating with anthracoal should produce 79 per cent more anthracoal in 24 hours than the same type of recovery oven. As the cost of manufacture in each case is almost the same, with perhaps a little greater expense involved in the preparation of the anthracoal mix, the 79 per cent greater production of anthracoal than coke in 24 hours more than offsets the loss of the by-products.
7. A non-recovery type oven should prove more adaptable to the anthracite region. Its cost will be less to construct than the recovery type, and it will not require a skilled staff of chemists and workmen.
8. No market need be developed or additional sales force required, as in the by-product game, but rather the maximum amount of fuel can be produced, which can be handled in conjunction with the sale of anthracite coal.

Naturally, the success of the anthracoal will not be proved until a plant has been erected and the ovens operated on a commercial scale for a period of time. As a non-recovery regenerative oven has been rarely used in this country, it will embody some changes in design from the regular regenerative type. However, this type of oven has been used with success in Germany and never presented any difficulties, as far as can be learned.

NEW DEVELOPMENTS IN THE MANUFACTURE OF TUNGSTEN AND ITS COMPOUNDS

Hugo Lohmann reports in *Electrochemisches Zeitung*, Vol. 26, pp. 29-33, that he has been able to make comparatively large quantities of the crude metal and to obtain therefrom a thoroughly fused carbide in a specially designed furnace. The latter was of the arc type, but was constructed in such a manner that the principal disadvantages of this kind of furnace—viz., the smallness of the source of heat and the space within which it can prevail—are eliminated. It was possible to melt 5 kg., or 12 lb., of amorphous tungsten within fifteen minutes in this furnace. The current consumption is very low. Besides the carbide of tungsten, carbides of titanium, vanadium, zirconium, silicon, boron and uranium were obtained as well.

The hardness of tungstic carbide is 9.8 on Moh's scale. This substance was produced in large quantities and was used with great success to replace the industrial diamond, bort, in all its applications. By melting the carbide it was found that it could be produced in a strong, compact state so that it could be employed in making dies for wire-drawing machines, in

fabricating cutting tools of all sorts, boring apparatus, etc. There appear to be important economic as well as technical advantages in favor of the carbide.

The melting of tungsten and the making of castings, forgings, etc., with the metal have rendered it usable for many purposes for which it could not be used hitherto. It was found that high-speed cutting tools made from tungsten gave very remarkable results in their durability and the thickness of the cut. Any tool or machine part that must stand up against extreme wear and exceedingly high temperatures caused by frictional resistance or otherwise has been improved very greatly by being made from the pure fused tungsten metal.

The author has prepared molten uranium at a temperature of 3,500 deg. Cent. in large quantities. He has used the metal in making the target in X-ray tubes and found that the results corroborated the theory that the higher the molecular weight of the target metal the more effective the X-ray apparatus. He also used the metal in making the contact points for the spark-plugs of gas engines, and instead of platinum for the contact wire in incandescent light.—Abstract from *Chemical and Metallurgical Engineering.*

SYNTHETIC ORGANIC CHEMICALS

The regulations issued by the Treasury Department for the enforcement of the dye and chemical control section of the Emergency Tariff Act contain the following definition of synthetic organic chemicals with provisions of interest to the chemical industry.

The terms "synthetic organic chemical and synthetic organic drug," used in said section 501-a of the emergency tariff act are interpreted to apply to any substance which is known commercially as a chemical or drug and which contains carbon in chemical combination with other elements (excepting cyanides, cyanamides, carbides, carbonates and bicarbonates of metals or inorganic radicals), and which has been produced by any chemical process other than that necessary to extract, isolate or purify the substance from a natural source or to effect its separation from a more complex natural compound by hydrolysis or to form a salt.

Products obtained by fermentation, if such fermentation is carried on under controlled conditions, are considered to be synthetic organic chemicals. Distillation which simply separates a substance already formed from other substances does not make the product of such simple distillation a synthetic chemical or drug, but if the substance is subject to destructive distillation the products of such destructive distillation are considered to be synthetic organic chemicals or drugs.

In those cases where a particular substance may be either a natural or synthetic product it should be assumed that the substance is a synthetic product if it is known that the product produced is of a substantial commercial quantity. In cases of doubt the question will be referred to the department.

It is held that compounds or mixtures in part of coal-tar origin are included in the term "mixtures and compounds of such coal-tar products" as it occurs in the act, and that it was not the intent of the act to limit the term to mixtures and compounds wholly of coal-tar origin. When a product has sufficient coal-tar product mixed or combined with it to change materially its identity or character it shall be considered a "mixture or compound of such coal-tar product" within the meaning of the act.

A CHEMICALLY CONTROLLED AUTOMOBILE

This was the subject of a paper by George G. Brown before the American Chemical Society at its New York meeting in September.

The average motor car is wasting twice as much energy in unburned gas in the exhaust as it is converting into useful work. This statement becomes obvious when we consider that the thermal efficiency of the average car is not over 15 per cent and from a large number of tests by the Bureau of Mines it was found that "The combustible gas in the average automobile exhaust amounts to 30 per cent of the total heat in a gallon of gasoline."

This loss, entirely preventable, is not only an expensive practice but a criminal waste of a valuable and limited resource.

Gasoline itself is not explosive. It can be exploded only when mixed with air in very definite limited proportions. If these limits are exceeded either by having too large a percentage of gasoline or too large a percentage of air the mixture cannot be exploded.

The combustion or explosion of a gasoline-air mixture as it takes place within an automobile engine is essentially a complicated chemical reaction, and as such is very susceptible to chemical control. The principle of chemical control is to determine the influence of all possible variable factors upon the desired reaction and then so to control these variable factors that the desired reaction will take place as completely and efficiently as possible.

In all industrial combustion problems increased efficiency can be obtained by returning as much heat as possible from the exhaust gases to the combustion zone by preheating the air. This is doubly true in the gasoline engine for hot air not only helps to vaporize the gasoline but also increases the rate of combustion so that a leaner mixture can be burned with increased efficiency. But another factor, known as turbulence, which results from the velocity of the mixture entering the cylinder, has an equally noticeable effect upon the rate of combustion; so that when a car driven under normal load, using the leanest possible mixture, encounters a hill or other added resistance, and slows down, the diminished velocity of mixture into the cylinder decreases the turbulence and velocity of combustion to such an extent that the engine backfires, misses, and may even stop unless some measure is employed to increase the velocity of combustion. This can best be done by supplying a richer mixture until conditions have returned to the former state of constant normal load.

The common experience of every automobile driver is to get the best mileage with a hot engine running on a lean mixture, but to climb a hill or thread a course through traffic with a smooth running, flexible engine a richer mixture is necessary. As it so happens that an over-rich mixture will give a flexible powerful engine although wasting a large proportion of gasoline as unburned gases, while a mixture the least bit too lean causes uneven running, and lack of power, most drivers run their cars on an unnecessarily rich mixture to be certain to avoid the annoyance of backfiring, missing, and difficult starting.

Repeated tests have shown that 30, 35, 40 miles per gallon and even more may be obtained driving at constant speed along a level highway and burning a lean hot mixture. It has always seemed reasonable, in spite of statements to the contrary, to expect that a carbureter could be developed that would automatically deliver the leanest and most efficient mixture possible with every temperature condition when the car is running under light load, and would automatically enrich the mixture according to decreased speed or increased load as the car encounters greater resistance so that quick acceleration, easy hill climbing, and flexibility need not be sacrificed for economy.

It has been found that the two variables, temperature of air and manifold suction, are sufficient in themselves to supply all the automatic control desired, as it is necessary to supply simply a leaner mixture with increased temperature and a richer mixture with increased load.

Working along these lines a carbureter has been designed from a scientific and mathematical standpoint that can be made to deliver a mixture of any proportions desired under any conditions.

It has been found possible, using this carbureter, to obtain 35 to 40 miles per gallon on a standard Ford touring car with equally quick acceleration and even more flexibility than could be obtained with standard equipment giving 20 miles per gallon under the same conditions.

SUBSTITUTES FOR ASH IN AUTOMOBILE BODIES

ASH has always been considered the most desirable wood for use in automobile bodies. It combines the properties of moderate weight, easy workability, high degree of toughness, and comparative freedom from warping. On account of the high price of ash, however, other woods are gradually replacing it in all but the most expensive cars.

The following description given in Technical Note No. 147 by the Forest Products Laboratory gives some of the advantages and disadvantages of the substitute woods as compared with forest grown ash for automobile construction:

Maple.—Hard maple is used for sills in many cars, and in some for the framework of the body and even the floor and running boards. Maple is fully as strong and stiff as a beam or post as white ash, but is not so shock-resistant. It is usually cheaper than ash and runs more uniform in strength. Maple warps very little, in this respect being superior to elm. On the other hand, maple is more difficult to season without checking than ash or elm, and it is said not to hold screws so well in motor car bodies. On account of the smooth, fine texture of maple, paint and enamel rub off it more easily, especially on curved surfaces which receive considerable wear, than off birch, which is slightly more porous. Because of its smooth-wearing qualities and comparative freedom from slivers, maple is preferred to all other woods for the floors of delivery trucks.

Elm.—The principal use of elm is for frames, seat backs, and doors; very little, if any, is used for sills. White elm is preferred to rock elm, except for some of the bent parts, because it is more easily worked and is less subject to warping. For the same reasons lumber from old white elm trees, usually called "gray elm," is preferred to that from younger or vigorously growing trees. Old white elm is not so strong or tough as ash, on the average, but it varies less in strength than ash, especially that which comes from the southern swamps.

Birch.—Yellow birch is a close rival of maple. It is used for sills, framework, and many minor parts. It is said to hold the paint better than maple on exposed parts.

Hickory.—The true hickories are used almost exclusively for spokes and felloes. The pecan hickories, which are somewhat inferior as a class to the true hickories, might be used in body construction, although their hardness and tendency to twist would perhaps prove a serious drawback.

Red Gum.—Red gum is too weak and soft for the sills and other major parts of the frame, but is used for floor boards, seat risers, and other minor parts. One of the principal drawbacks to the use of gum is its tendency to warp with changes in moisture content. Quarter-sawed gum gives less trouble in warping than plain-sawed gum.

Oak.—In automobile construction no distinction is made, as a rule, between the different species of oak or even between the red oak and white oak groups. In truck bodies, oak is one of the leading woods, being used for sills, cross sills, frames, floors, and stakes. In pleasure cars oak is rarely used for the frame or sills. Wormy oak is used for running boards, floor boards, and seats, and some sound oak for instrument boards and battery boxes. Top bows are made almost exclusively of oak, second growth being preferred.

Southern Yellow Pine.—Under this heading are included longleaf, loblolly, shortleaf, and some of the minor southern pines. These have been found adaptable for running boards, floor boards, seat boards and a number of small parts in the seats and frames.

Other Species.—Cottonwood is used for dash boards of pleasure cars and the boxes or bodies of trucks. Sycamore, beech, basswood, yellow poplar, cucumber, tupelo, gum, chestnut, Douglas fir, and western yellow pine have also entered into car body construction to a small extent.

The comparative merits of the different species in the four properties most important in automobile construction are given in the following table, the strength of forest-grown white ash being taken as 100. Actual strength values of these species are to be found in Department of Agriculture Bulletin 556, "Mechanical Properties of Woods Grown in the United States."

Strength of Woods Used in Automobile Construction in Per Cent of the Strength of Forest Grown White Ash

Species	Strength as a beam or post	Stiffness	Shock resisting ability	Hardness
HARDWOODS				
Ash, white, forest grown	100.0	100.0	100.0	100.0
Ash, black	71.3	79.3	90.1	62.3
Ash, white, second growth	122.5	117.6	119.6	118.9
Basswood	59.1	80.6	40.5	29.6
Beech	93.5	96.9	96.0	90.0
Birch, yellow	104.8	116.8	120.6	80.9
Chestnut	66.0	71.9	53.4	49.2
Cottonwood	60.6	79.0	54.3	35.3
Cucumber	85.4	112.4	76.7	54.9
Elm, rock or cork	98.8	92.9	140.5	101.6
Elm, white	79.2	79.5	89.5	57.1
Gum, red	80.7	91.5	75.5	59.0
Gum, tupelo or cotton	81.4	82.5	63.5	77.3
Hickories, pecan	103.5	103.8	119.7	139.6
Hickories, true	126.6	120.2	173.9	150.4
Maple, red	90.0	101.2	78.7	75.4
Maple, silver	66.9	68.5	71.7	64.3
Maple, sugar	104.7	105.9	90.5	103.0
Oaks, all kinds	92.6	101.3	94.9	104.5
Poplar, yellow	67.3	93.8	41.5	37.9
CONIFERS				
Fir, Douglas	95.7	122.1	59 9	58.3
Pine, loblolly	93.7	105.6	71.0	60.0
Pine, longleaf	112.2	122.1	77.7	74.8
Pine, shortleaf	94.1	100.6	69.7	64.0
Pine, western white	75.5	99.7	53.8	37.0
Pine, western yellow	67.0	75.6	42.9	41.0
Spruce, Sitka	69.5	94.1	63.3	44.9

SOLUBLE OILS AND THEIR PRODUCTION

SOLUBLE oils have become an important item in many industrial processes as for example in tanning. The July issue of the *Journal of the American Leather Chemists Association* prints the following abstract of R. Sansone's discussion in *Le Cuir* 10, 13 and 156 (1921), entitled "Notes on Soluble Oils and Their Production."

The commercial soluble oils can be grouped: (1) emulsifiable oils; (2) sulfonated oils; (3) liquid soaps; (4) soluble mineral oils. Without doubt the first emulsifiable oil used in the tannery was prepared from olive oil, preferably from the olive oil of Gallipoli which always contains large quantities of free fatty acids, up to 25 and 30 per cent. In absence of this particular oil any olive oil is submitted to artificial oxidation and upon mixing with water for fat liquor forms a more or less stable emulsion. The high price and food value of olive oil, especially since by simple chemical treatment low-grade olive oils can be rendered edible, are constantly reducing the use in the tannery of this oil which in the near future will be replaced by a mixture of fatty acids and lowest grade olive oil, or simply a mixture of fatty acids with cottonseed, fish or peanut oils treated artificially to give the odor of rancid olive oil. Sulfonated oils may be classed as: (1) with castor oil base; (2) with olive oil base; and (3) with fatty acid base. Sulfonated castor oil while the best is also very expensive. Its value is often wrongly judged from the per cent fatty acids and fatty matter. This method is poor since in many cases it is easy thus to mistake for sulfonated castor oil a product made from cheaper oils. One of the first indications of genuine sulfonated castor oil is its bright color. Comparison of the melting point of the fatty acids with those from

an authentic sample should be made. Rosin soaps are often used in adulteration but these can be readily detected by color and characteristic odor. Sulfonated castor oil can be easily prepared. To the castor oil add ¼ its weight of 66° sulfuric acid keeping the temperature below 35-40° C.; let the mixture stand 24 hours, stirring it frequently; wash out most of the acid with water, siphon off the oil and neutralize remaining acid carefully with ammonia. A well prepared product upon dilution with water and addition of ammonia will remain clear. Vats for sulfonating oils are described. The vats are of hard wood and should have a capacity of 2½ to 3 times the volume of the oil to be treated. They should be provided with a gage and with spigots at different levels for drawing off the various reaction products and wash waters. Agitation during sulfonation preferably should be done by mechanical means. Vats of ordinary wood should be lined with lead as otherwise the action of the acid on the wood gives a dark product. As the sulfonation generates heat, the acid should be added a little at a time, taking at least an hour and the temperature should not rise above 40° C.

Sulfonated castor oils are ordinarily sold as containing 50 per cent fatty acids; sometimes oils are offered having up to 70 per cent and other times down to 33 per cent. All things considered the most suitable oils run 50 to 80 per cent fatty acids. The following tests for sulfonated oils are described: To 100 cc. of water 10 cc. of the sulfonated oil is added and the whole is agitated for some time. Upon standing a perfect emulsion should persist which should become clear upon the addition of ammonia. If the water is hard the emulsion should remain without change for an hour. To 1 liter of water are added 2½ cc. of 50 per cent acetic acid, 5 cc. of 8° Bé solution of calcium acetate and ½ cc. of a 10 per cent solution of the sulfonated oil. No change should be manifested even after boiling. To 1 liter of a solution containing 7.2 gms. of sulfuric acid (66° Bé) and 4.5 gms. of crystallized sodium sulfate is added 1 cc. of the sulfonated oil. Boiling for 1 hour should not cause any kind of separation.

For sulfonation the oil should be of good quality, free from water and the sulfuric acid should not cause any discoloration of the product. Before using any lot of acid it is best to make a complete sulfonation and fat-liquoring laboratory test of it. With the object of reducing the cost of production some manufacturers neutralize the sulfonated castor oil as soon as the acid water has been separated, thus avoiding all water washing; others reduce the quantity of ammonia required by substituting caustic soda for 4/5 of it and using the ammonia only toward the end of the operation. Castor oil has been preferred for sulfonation because in the sulfonated state it forms soluble soaps with the minimum proportion of alkali. Because of the high price of castor oil some manufacturers have returned to the use of olive or other oils; some to mixtures of olive and castor oils; and still others to fatty acids for sulfonation. Olive oil may be sulfonated as follows: 100 kgs. of oil are mixed with 20 kgs. of sulfuric acid (66° Bé) in a container of 500 liters. The mixture is allowed to stand one day and then thoroughly mixed with a solution of 10 kgs. of calcined sodium carbonate until effervescence ceases. The vat is then filled with water and left for about 2 days to clear up after which the acid water is drawn off and the oil mixed with a solution of 4 kgs. of caustic soda in 85 liters of water and neutralization is completed by the addition of ammonia to a faint alkaline reaction. Neutralization should be done at a temperature of 25°-35° C. In the above manner a sulfonated olive oil is obtained which contains 33 per cent of fatty acids. A mixture of sodium sulforicinate and olive oil is often sulfonated, although it is not as certain as separate sulfonation. The sulfonation of oleic acid is important because of the large quantities of this product as a residue from the manufacture of candles and glycerine. One of the most usual preparations is obtained by sulfonating 260 parts of oleic acid with 90 parts of sulfuric acid for 12 hours. The sulfo-oleic acid thus formed is left for 24 hours, then washed with a solution of common salt and neutralized with caustic soda and ammonia. These sulfonated oils are cheap and readily soluble in water. They can be substituted for many purposes in the tannery.

Monopol soap is a special form of sulfonated oil. It is prepared sometimes by treating 100 parts by weight of castor oil with 50 parts of 66° sulfuric acid in such a manner that during the sulfonation no sulfurous acid is developed. The mixture is left to cool during 1 or 2 days with vigorous stirring from time to time. According to these proportions there are about 3 molecules of sulfuric acid for each molecule of castor oil giving thus a higher degree of sulfonation. It is upon this that the success of manufacturing depends. The temperature should be maintained between 25°-30° C. The product thus formed is then treated by one of the following procedures: To 100 kgs. of the above acid mixture, 60 kgs. of 36°-37° Bé caustic soda, are added at once while stirring. The oily mass becomes limpid and yellow. It is left for 2-3 days, during which time sodium sulfate crystallizes out. The crystals are removed and the oily mass is heated up until upon cooling it forms a soap called "Monopol." If the operations have been properly conducted and the necessary quantity of alkali correctly calculated the final product will not be acid enough to turn litmus. The second procedure is to wash each 100 kgs. of the acid mixture with 100 to 200 liters of a warm solution of common salt (25°-30° Bé) to remove the excess of acid. After thorough mixing, the mixture is left for several days and then for each 100 kgs. of the washed oil 39 kgs. of caustic soda (36°-37°) are added at once with stirring. A nearly saturated solution of common salt gives good results in promoting the formation of a solid soap. For the tannery however this is not important and the operation could be concluded after neutralization, leaving the soap in liquid form. Monopol soap is considered an acid soap of very great emulsifying power. If it is heated for 4 hours at 100° C. and then completely neutralized a product of emulsifying power equal to that of sulfonated castor oil is obtained. A soap which dissolves completely in water may be obtained by treating a mixture of 60 parts of oleic acid with 30 parts petroleum oil with a trace of some condensation agent, such as aluminum chloride. The reaction takes place quickly at 60° C., the mass becoming solid and dark. After decanting the necessary amount of alkali is added for saponification. The reaction is based on the property of oleic acid of combining with petroleum oil in presence of a condensation agent.

CHEMISTRY IN FINISHING LACE CURTAINS

W. Albert in *Deutsche Färber-Zeitung* discusses the bleaching and finishing of lace curtains in an article abstracted as follows in the August *Color Trade Journal*:

As far as the manufacturer is concerned, lace curtains may be divided into two classes: (1) those that are bleached white, and (2) those that are dyed in various tones of cream color and are unbleached. In the bleaching of lace curtains, owing to the rather delicate nature of the material, as little handling as possible should be given the goods, and the bleaching should be suitably provided with the proper machines and appliances specially adapted to the handling of this material in kier-boiling, washing, bleaching and drying. As far as the bleaching operations are concerned, these are conducted very much as other forms of cotton bleaching. The following treatment is recommended:

(1) Steeping over-night in a weak solution of soda ash;

(2) Boiling for 6 to 8 hours under 1 to 2 atmospheres pressure in a closed kier with a lye containing 10 per cent (on the weight of the goods) of caustic soda;

(3) Washing with warm water in the kier;

(4) Washing thoroughly with hot water in a suitable roller washing machine;

(5) Souring in cold sulfuric acid at 1° Tw. with subsequent steeping in the solution for 1 hour;

(6) Washing to remove the acid and dissolved impurities;

(7) Boiling a second time, using 5 per cent of caustic soda for 5 hours;

(8) Washing again in the roller washing machine;

(9) Chemicking in chloride of lime solution or sodium hypochlorite at 1½° Tw., the goods being steeped in the liquor and the latter circulated for 2 to 3 hours or until a satisfactory bleach is obtained;

(10) Washing in the roller washer;

(11) Souring in sulfuric acid at 1° Tw. with circulation of the liquor;

(12) Washing thoroughly to remove acid.

The goods are finished by passing through a weak bath of soda ash at 110° F., then sizing with starch paste to the desired quality and stiffness. With the cheaper grades of material, filling and loading ingredients such as china clay, etc., are added to the size. If a very stiff handle is desired some gelatin is added to the starch mixture. Sometimes magnesium chloride is also added for weighting, as this absorbs considerable moisture. For tinting, Ultramarine Blue is generally used in the size, although Indanthrene Blue RZ is also an excellent tinting medium. Creamed curtains are, as a rule, not bleached. The tinting may be done with ochre mixed with water, the goods being run through this bath and the ochre being added to the size. For the drying of curtain material specially constructed frames or tenters must be used so that the fabric is not injured, and yet so dried and stretched that the design is symmetrical and not distorted. After drying the goods are finally calendered under pressure.

MODERN GRINDING

Harlowe Hardinge in the August 10 issue of *Chemical and Metallurgical Engineering* gives a very interesting discussion in "The Economy of Modern Grinding Methods" from which these questions which should be a guide in purchasing grinding equipment are taken as well as a table showing the modern classification of grinding:

Is it the type of equipment to perform your work properly?

What is the total first cost of equipment and auxiliary apparatus f.o.b. factory?

What is the total cost of freight for equipment and auxiliary apparatus to go with this equipment, if any?

What is the cost of erection, including buildings, foundations, etc.?

What floor space is required?

What head-room is required?

Is the equipment self-contained?

Is it easy to inspect when located in the building as you have planned?

What power is required to start and what power to operate?

Is the equipment and lay-out designed so that it is dustless if grinding dry, or water-tight and clean if grinding wet?

What repair parts will have to be kept on hand?

What will be cost of repairs per ton of material ground?

What labor will be required to operate the grinding equipment? Will it have to be skilled and how much time must be allotted?

What percentage of operating time is assured after the equipment has been in operation one year?

Is the equipment simple in design and does it require constant attention to keep oiled or parts tight?

What facilities are there for feeding or discharging automatically?

Is the unit as a whole flexible—*i.e.*, will it wear itself out if underloaded or overloaded?

What troubles are liable to follow, either in loss of production or otherwise, due to choking or jamming of working parts?

Has estimate of capacity been based upon actual conditions that you will maintain, such as maximum size of feed, fineness of product, moisture content and hardness of material?

CLASSIFICATION OF GRINDING

DRY GRINDING

Granular Grinding	
Carborundum, emery, silica and ganister rock	For abrasives.
Salt	For table use.
Iron and metals	For recovery from gangue or waste.
Chemicals	For aid in chemical processes.
Grog	For manufacture of tiles, porcelain ware, etc.
Mica and slate	For roofing.
Asbestos	For obtaining fiber.
Medium Fine Grinding	
Limestone	For asphalt filler and agricultural purposes.
Barytes and coal mixture	For manufacture of paint (base).
Phosphate rock	For fertilizer.
Sulfur	For chemical compounds.
Iron and minerals	For concentration or separation by special processes.
Hard rubber	For manufacture of rubber composition.
Sawdust	For chemical purposes.
Cast-iron borings	For chemical purposes.
Fine Grinding	
Limestone	For the manufacture of cement.
Clinker	For the manufacture of cement.
Coal—bituminous and anthracite	For burning under boilers, in kilns, driers, furnaces, etc.
Grain—various kinds	For food purposes.
Feldspar	For pottery manufacture.
Mica	For use in tire grades.
Extremely Fine Grinding	
Barytes	For use as a paint base.
Filter cake	To prevent formation of lumps in further processes.
Grain	For best grades of flour for food.
Pigments	For the manufacture of paints.
Pumice stone and emery	For dental purposes.
Graphite	For pencils.
Talc	For paper filler, talcum powder, etc.

WET GRINDING

Granular Grinding	
Ores	For extraction of minerals by jigging and table concentration.
Clay	For recovery of diamonds.
Graphite schist	For recovery of flake graphite from waste rock.
Medium Fine Grinding	
Ores	For extraction of minerals by amalgamation and flotation processes.
Foundry waste	For reclamation of metal contained therein.
Iron pyrites	For manufacture of sulfur.
Fine Grinding	
Ores	For extraction of metal by cyanidation.
Mica	For wall paper trade.
Feldspar	For use in pottery manufacture.
Extremely Fine Grinding	
Barytes	For paint base.
Carborundum and emery	For glass polishing.
Limestone	For manufacture of whiting.
Pigments in water	For manufacture of colors.
Pigments in oil	For manufacture of oil paints.
Ink	Incorporation of carbon and other materials in oil.

WATERPROOFING COTTON FABRICS

In the *Textile Colorist* A. J. Hall discusses the properties and preparation of aluminum formate and acetate used in waterproofing. He also outlines the tests which he has found most suitable in exercising the control necessary to the success of the method:

"Although many million yards of fabric are waterproofed each year a thoroughly satisfactory water-resisting material has yet to be produced. The chief difficulty is encountered be-

cause a perfectly waterproofed fabric is usually non-permeable to air, whereas the demand is for a fabric in which water resistance is united with air permeability.

"There are several methods for waterproofing which have met with varying degrees of success. Generally speaking, a rubbered fabric has the most satisfactory water-resisting properties, but as opposed to this, rubber is particularly susceptible to grease and is non-permeable to air. To the same type belong those fabrics waterproofed with a drying oil such as is obtained by mixing raw and boiled linseed oils. In addition to non-permeability to air such fabrics are liable to crack.

"Not much waterproofed fabric (although the process is frequently used for paper) is produced by means of cellulose solutions. But fabric which has been treated with cuprammonium solutions of cellulose is highly resistant to mildew. This is probably because of the presence of a small amount of copper remaining in the fabric.

"In many respects waterproofing with aluminum soaps is the most satisfactory process. Certainly the fabrics so treated do not lose their permeability to air. Their power of water resistance is not exceptionally good, but it is quite sufficient for many purposes. Fabrics proofed with aluminum soaps will withstand a fair amount of handling without marked deterioration. A further good feature of the process is that it can be easily carried out and is conducive to a good output.

"The waterproofing process consists of padding the fabric with a soap solution suitably colored according to the fabric being treated. It is then partially dried on drying cylinders through which a reduced amount of steam is passing. The fabric is then passed through the solution of the aluminum salt and afterwards dried to the usual extent.

"It is obvious that the process cannot be well carried out if the chemicals used are not accurately balanced. While the soap used can be generally obtained of a uniform quality, the acetates and formates of aluminum are always sold in the form of solutions, and so are liable to much variation in strength.

"The strength of aluminum salt solutions is usually determined by their specific gravity. Thus aluminum acetate is usually sold as a liquid, free from iron, and standing at 15-20° Tw. But this standard is considerably indefinite, since the density of the solution is affected by all the soluble impurities present. So that the only way of insuring the success of a waterproofing process is to control rigorously the strengths of the aluminum salt solutions by means of chemical analysis."

RECOMMENDATIONS FOR COTTON RESEARCH

AT the World Cotton Conference recently held in England the following recommendations were made regarding research:

"The Committee on Research and Statistics believe that, in considering the matter of research, the primary aim should be to formulate resolutions which will lead to constructive action.

"It is the belief of the Committee that there is a vital need in the cotton industry for scientific research and the application of exact knowledge.

"It strongly endorses the sentiments expressed by Doctor Crossley when he states that, while business privacy and publication of results would appear to be incompatible, a solution can and must be found, for science demands the free discussion of results between those best qualified to speak, no matter whether they are employed in private, in industrial, or in University Research Laboratories.' "

1. With this belief in mind the committee suggests the following as suitable subjects on which to exchange scientific data:

(a) Methods of testing fibers, yarns and fabric with the object of securing, so far as possible, international methods "and a uniform system of expressing results."

(b) Information regarding the growing of cotton.

(c) Such other problems as may later be agreed upon by the International Cotton Research Committee.

2. That the Committee believe that it is above all important to organize in some way, to make an exchange of information effective, and therefore makes the following recommendations:

(a) That the countries represented at this Conference be urged to form National Cotton Research organizations on the lines of the British Cotton Ind. Research Association.

(b) In order to facilitate research work and the exchange of scientific data, that an International Cotton Research Committee be approved by this Conference.

(c) That the duties of this International Committee shall be to stimulate research in the respective countries and bring together scientific information on which it had been recommended that information should be exchanged.

(d) That each country having delegates to the Group on Research and Statistics of this Conference be hereby asked, through its delegates, to appoint sufficient representatives to this International Cotton Research Committee to represent adequately its various important research organizations and interests. For the purpose of voting, however, at any future Conference, delegates to the Research and Statistics Committee will be chosen in accordance with the Constitution and By-laws of the Conference.

TEMPERATURE SHOCKS IN HEAT TREATMENT

AT the annual meeting of the American Society for Testing Materials the Committee on the Heat Treatment of Iron and Steel submitted notes covering suggestions relative to avoiding temperature shocks in the heat treatment of metals. These notes are quoted herewith:

The advantage of alloy steels over simple steels lies in the fact that they are more sensitive to heat-treatment and capable of giving higher properties when properly handled. The increased sensitiveness to treatment unfortunately is accompanied by a proportionate sensitiveness to failure during treatment, which requires greater care in all treatment operations and necessitates the elimination of abrupt changes in section. The following suggestions are made to overcome this difficulty:

1. Heavy solid alloy forgings should not be allowed to cool, but should immediately be put in an annealing furnace and normalized.

2. High nickel-chrome, chrome-vanadium or any other alloy-steel bars and small forgings liable to shattering should be cooled slowly after rolling by burying in warm ashes or lime to retard the cooling. High carbon, even with a moderate alloy content, increases the risk of cracking.

3. A thorough annealing or normalizing above the upper critical point after rolling or forging eliminates much danger of later troubles due to cracks and strains and leaves the metal in a better condition to secure the maximum effect of the quench.

4. Annealing only does not develop high physical properties, but leaves the metal soft, uniform and ductile. To break up forging and rolling structures which are detrimental the piece should be double annealed, first at 100 to 200 deg. Fahr. above the critical range followed by an anneal slightly above the critical range.

5. In heating for either annealing or quenching, the piece should be slowly and uniformly brought to temperature, the rate depending on grade and section, especially through the brittle range, which is up to 800 deg. Fahr.

6. For quenching, the piece should be uniformly heated above the critical range and introduced into the quenching medium with no delay after leaving the furnace.

7. Quenching is the most drastic treatment operation, and therefore the most dangerous. Alloys or sections subject to water cracks should be quenched in circulating oil.

8. In drawing after quenching the piece must be slowly and uniformly heated to the proper temperature, but may be cooled slowly or rapidly as desired.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

THE OILGEAR—A VARIABLE SPEED- AND FEED-CONTROL SYSTEM FOR MACHINE TOOLS

Description of a speed-control system employing what appears to be some novel devices and permitting a large number of variations without stopping the machine.

The pump unit of the oilgear system comprises a revolving driver carrying five or seven crossheads and plungers with a corresponding cylinder barrel revolving with the driver and carrying the cylinders in which the plungers reciprocate. By shifting the center of the cylinder barrel the stroke may be varied to suit the conditions to be met. This stroke variation may be met either directly by the operator or controlled by an outside influence, such as pressure, temperature, centrifugal force, etc.

The motor unit may either be a simple plunger or a revolving multiple plunger unit similar to the pump, except that in the motor the plungers generally have a constant stroke, so that stroke changing mechanism is absent. Because of this the speed of the motor is dependent upon the rate at which the working fluid is delivered by the pump and it varies as the stroke of the pump is increased or diminished.

In addition to this, there is a third unit called the gear pump and acting as a make-up pump for the system. It draws working fluid which is usually oil from the surplus supply and keeps several pounds' pressure constantly on the intake line of the main pump. It may be also used as a means of rapidly transversing the tool carriage at a speed many times that required for feeding.

The principal unit in the feed-control system is the feed controller. This is essentially a casing including a small variable delivery pump having a capacity suitable for the small volumes called for in feeding tool carriages, a much larger constant delivery pump (gear pump) for rapid traverse, a stroke-changing mechanism whereby the operator can accurately set the variable pump stroke-changing handle, and operating to selectively connect one or the other of the two pumps to the feeding motor according to whether feeding movement or rapid transverse movements are required at the moment.

The plungers are fitted in radial reamed cylinders in the circular cylinder barrel, closely fitted for rotation on a hardened and ground ported pindle and fitted into a swinging arm by means of which the revolving cylinder barrel may be shifted from one side to the other of the revolving driver carrying and operating the plungers. Both driver and cylinder barrel continuously revolve around centers which coincide when the swinging arm is placed in central position and whose distance from one another may be increased in either direction by swinging the arm either to right or left. As the cylinder barrel axis is moved to right or left the length of stroke of the plunger is correspondingly increased, and results in a flow of oil through the pump in direct ratio to the length of stroke. This mechanism also gives a reversal of the flow, oil passing through the pump in one direction when the swinging arm is moved to the right, and in the opposite direction when it is moved to the left.

The cam is made with extreme accuracy, giving a speed variation for the tool carriage capable of the finest degree of adjustment. Moreover, after the cam has been swung about through a certain angle it again returns the cylinder barrel to neutral position, thus cutting off the flow from the high pressure pump and preparing the way for further swing of the control valve which connects the flow from the gear pump to the feed motor, to effect the rapid traverse.

The feed cylinder or motor on a machine tool must have hydraulic fluid on both sides, and the entire system including pipe connections must always be full of fluid under a moderate pressure to exclude air and insure an absolutely steady movement of the tool carriage. The maintenance of this make-up pressure, return of leakage, etc., is an additional function of the gear pump.

Two types of feeding motors are employed—the direct-acting pushing cylinder and the rotary motor.—*American Machinist*, Vol. 55, No. 6, Aug. 18, 1921, pp. 271-274.

HIGH-CAPACITY CONSOLIDATION TYPE LOCOMOTIVES

During the past 10 or 12 years locomotives of the Mikado type have to a large extent displaced consolidation in heavy main line freight service. The consolidation is still used to a considerable extent, especially for heavy track service where slow speeds suffice and fuel conditions do not require the boiler and firebox proportions that can be obtained in the Mikado type. The purchase of 40 heavy consolidation type locomotives by the Western Maryland Railway and the use of locomotives of the same type purchased a few years ago by the Delaware and Hudson Company show vitality of this type. In particular, it is claimed that with driving wheels of the size that are suitable for slow speed heavy duty service, it is possible in a consolidation design to use a firebox throat of sufficient depth to install a brick arch without raising the boiler to an excessive height.

Among the practical features of the new Western Maryland locomotives may be mentioned the following:

The frames are 6 inches wide, spaced 41 inches between centers, and each frame is cast in one piece with a single front rail to which the cylinders are bolted. A substantial steel casting, placed just back of the cylinders, extends the full length of the leading driving pedestals and serves as a fulcrum for the driving brake shaft. Guide yoke crosstie is also of cast steel, and it is extended back sufficiently far to brace the second driving pedestals. This crosstie also serves as a support for the driving brake cylinders, one of which, because of the lack of room, is placed in a horizontal, and the other in a vertical position.

The driving boxes are of cast steel, and are fitted with bronze hub faces and brass-lined pedestal faces. Cast iron shoes and wedges are used, the latter being of the self-adjusting type. The driving axles and engine truck axle are of heat treated steel, and flanged tires are used on all the wheels. Flange oilers are applied to the front and back drivers. The ashpan has two hoppers with swing bottoms, both of which are controlled by one handle. Flushing pipes are applied for washing ashes from the slopes of the pan. The injectors and steam turret are placed outside the cab and have extension handles identified by small aluminum plates with raised letters. The equipment includes a breather pipe for providing fresh air while passing through tunnels. This arrangement consists of ½-inch pipe placed across the boiler back head, and having five ¼-inch globe valves equally spaced, each fitted with three feet of ½-inch hose. The air supply is drawn from the brake system.

In the Delaware & Hudson consolidations, the design of the ashpan proved to be quite a difficult problem which was met by the construction of an ashpan having six distinct hoppers and doors. Ample air-way for combustion requirements is provided through a 6-inch opening between the pan and the mud ring. The tender construction is also big for a locomotive of this capacity in that it is supported upon an underframe of

built-up structural shapes with heavy center sill section, such as is employed in car construction.

In the Delaware & Hudson units the per cent of boiler horsepower to cylinder horsepower is higher than in the Western Maryland (92 as compared with 85 per cent) and this difference is ascribed to the relatively larger percentage of firebox heating surface to total heating surface in the Delaware & Hudson Consolidation, since each square foot of firebox surface is equivalent in evaporating capacity to more than 5 square feet of tubular heating surface. This only serves to emphasize the inherent limitation in the consolidation type locomotive. On account of the limited flue length and firebox dimensions, it is impossible to secure horsepower equal to cylinder horsepower in high capacity locomotives of this type without the use of thermic syphons or other means of augmenting firebox or tubular heating surface.—*Railway Review*, Vol. 69, No. 7, August 13, 1921, pp. 197-205.

FLOW OF WATER THROUGH GALVANIZED SPIRAL RIVETED STEEL PIPE

By F. W. Greve

Data of experiments performed in the hydraulic laboratory of Purdue University. The diameters of pipes tested were 4, 6, 8 and 10 inches, respectively. The average spacing of the rivets was 7/8 inch for the smaller and 1 1/8 inches for the larger pipe. The rivet heads on the inside of the pipes projected 1/10 inch from the pipe wall and were flattened to reduce the resistance to flow.

The relation of friction head per 100 feet of pipe to velocity of flow both with and against laps, is shown in the original article by a graph. The graphs are straight lines indicating that the head loss varies directly as some power of the velocity. They are nearly parallel lines which demonstrate that the slope varies but little with the size of pipe. From the figure it also appears that the loss decreases with increase of diameter for any given velocity; that the loss is greater for flow against than with laps, and that the difference of loss with and against laps decreases with increase of diameter. It would appear, therefore, that the flow in large sizes approaches the conditions of smooth pipes.

The friction loss may be expressed as $\frac{h}{L} = mv^n$ where $\frac{h}{L}$ is the loss due to friction expressed in feet of water; v is the true mean velocity in feet per second; m is the value of $\frac{h}{L}$ when v is 1 ft. per sec. and n is the slope that the graph expressing the relation of $\frac{h}{L}$ to v makes with the horizontal.

The original article gives a table showing certain of the variations of m and n, these relations being of such a character that they are readily established. On the whole it would appear that the friction loss in galvanized spiral riveted steel pipes when the flow is with the laps is still different from that in smooth cast iron pipes.—*Engineering News-Record*, Vol. 87, No. 4, July 28, 1921, pp. 159-160.

TRENT PROCESS FOR CLEANING POWDERED COAL

By B. P. Hood (Mem. Am. Soc. M.E.)

Description of a process now under investigation by the U. S. Bureau of Mines and U. S. Bureau of Standards. The process belongs to a class of those where differential wetting is used and essentially consists in agitating together powdered coal, water and oil. This produces a partly de-ashed plastic fuel, called an amalgam, the oil selecting the coal particles and largely excluding the water and ash. The amalgam can be freed from water mechanically held by working, much the same as butter is worked. It can be burned by shoveling or forcing through pipe by pressure and can be stored if desired under water.

If an oil is used which can be distilled at a temperature below the distilling temperature of the coal, powdered fuel is reclaimed from the amalgam and the oil may be re-used. If a heavy oil is used and distilled to dryness a coke product may be recovered, although the coal used may have had no coking quality. If the distillation proceed only to a heavy pitch, a mass suitable for briqueting may be made.

From a paper by G. St. J. Perrott and S. P. Kinney of the Bureau of Mines it would appear that in this process the clean separation of mineral matter from combustible matter is obtained and combustible recovery has averaged better than 95 per cent.

It has not been found feasible to treat the lignites without preliminary carbonization, due to the difficulty of forming a coherent agglomerate of the raw lignite and oil.—*Iron Age*, Vol. 108, No. 6, Aug. 11, 1921, p. 323.

BIG CREEK DEVELOPMENT OF THE SOUTHERN CALIFORNIA EDISON COMPANY

By F. H. Rogers

Description of a 30,000 horsepower unit designed to operate under a 680-foot head at a speed of 428 revolutions per minute. It is of the vertical shaft single-runner Francis type and is directly connected to a 22,500-kilowatt 14-pole 50-cycle 11,000-volt generator. The water is led to the turbine through a penstock 2800 feet long, having a diameter of 7 feet at the top and 6 feet at the bottom.

Particular effort was taken to reduce leakage at the runner seals, which is an important factor in the design of high-head units. In this case it is claimed that it is considerably reduced by the use of the Moody labyrinth seal device. In this leakage water must pass through a series of six seals at each of which the velocity head is destroyed owing to changes in section and direction of flow. It is claimed that the effective head causing the leakage is only 1/6 of the head for a single seal and that the use of this device will reduce the leakage to only about 0.9 per cent of the full load quantity, which is about one-third of that which would occur with the single seal.

As the operation of the unit is continued this leakage loss increases, since the wear at the seals is directly proportional to the velocity of flow through the passage and as this velocity is about three times as great for the single seal as compared to the labyrinth seal, the wear at the former would be about three times as rapid as for the latter type. It is claimed that after continuous operation for a period of a year the leakage through the labyrinth seal would be only 22 per cent (as compared with 33 per cent for a new turbine) of the leakage occurring with the single seal.

In the usual design of the guide vane there is constant leakage between the top and bottom of the vane and the distributor plates and as this water is not properly guided by the vane it strikes the runner vanes at an incorrect angle causing considerable trouble. The guide vanes in this plant are of the type known as the Overn disk vane in which two heavy disks are cast at the junction between the vane and the upper and lower seams. When installed in the turbine the faces of these disks are flush with the distributor plates, so that they prevent any flow above or below the guide vane proper, except for that small portion of the vane which extends beyond the disk. As a result all the water is guided to the runner faces at the proper angle, and when the vanes are in the closed position there is very little leakage.

One of the interesting features of the governor control is the method of change from governor to hand control. In former designs this change usually entailed the closing of three or four large governor valves and the opening of three or four smaller hand-control valves under high pressure. This not only take considerable time but might lead to serious trouble in case the operator through excitement closes the valves in wrong sequence. In the present installation the governor is furnished with an automatic device known as the Taylor control system, consisting of plunger valves in the governor base operated by oil pressure from the governor system.—*Power*, Vol. 54, No. 7, Aug. 16, 1921, pp. 244-248.

STELLAR PHOTOGRAPH EVIDENCE FOR EINSTEIN'S RELATIVITY THEORY

B. H. Crookes, writing in *Chemical News*, on the basis of hitherto unpublished experiments by W. G. Crookes, suggests that the displacements of the star images obtained in the 1919 eclipse, and accepted as evidence of the truth of Einstein's theory, may have occurred, not during exposure, but subsequently during development and fixing. That the latter can occur in photographs of spectra of the elements was suspected, tested, and proved by him, the test being made in the following manner: A negative, with two spectra, slightly overlapping, was selected, which had at one part of it a group of strong lines, and at another part few and weak lines. From this negative a contact positive was printed, and from the positive another contact negative. The two negatives were then measured in the usual manner, along the overlap of the two spectra, and compared, and the following results noted: (a) the whole negative altered in length; (b) the alteration took place in a "concertina" fashion, being greater where the lines were strong and numerous than where they were light and few; (c) one or two lines showed decided displacement with regard to their neighbors in the same spectrum. The conclusion drawn was that during development and fixing the sensitive film was in a state of tension, and yielded to the strain irregularly in proportion to the depth and width it had been altered by the light rays. It would then seem that the spectra had been measured along the very worst line, where distortion would be greatest, and arrangements were being made to alter the shuttering of the spectroscope so that the measurements could be taken along a line only just off the unexposed part of the plate, where distortion would be least, but death intervened, and the alteration was never made. In the case of stellar photographs there would appear to be no line of weakness, but in the eclipse the ring of flames would form a very decided line of weakness, and the author suggests the desirability of examining the possibility of the displacements having arisen from the sensitive films having yielded to strain in its neighborhood during developing and fixing. If this should be the case, a similar effect should be found, he suggests, during an annular lunar eclipse, and it might even be possible to obtain evidence of slight displacement during a close conjunction of a star with Jupiter or Venus when at their brightest. Bright star clusters might also show systematic divergencies between the photographic and visual positions.

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